

Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area

Groundwater Management Plan Update



San Luis & Delta-Mendota Water Authority

July 2011

Revised November 7, 2011

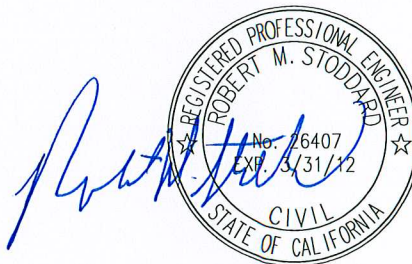
Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area

San Luis & Delta-Mendota Water Authority

Client Frances Mizuno
Representative

AECOM Technology Corporation

Project Engineer Robert M. Stoddard, PE



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Section 1

Introduction

In 1995, the San Luis & Delta-Mendota Water Authority (SLDMWA) entered into an activity agreement with its member agencies; City of Tracy, Plainview Water District, Del Puerto Water District, Banta-Carbona Irrigation District, West Stanislaus Irrigation District, Patterson Water District and the Westside Irrigation District to provide an umbrella organizational structure for managing groundwater resources. Those members adopted a Groundwater Management Plan for the NA-DMC service area (GMP-NA) based upon the requirements of AB 3030, which GMP-NA characterizes the groundwater basin; reviews factors of the water resources balance, including groundwater; estimates basin-wide groundwater pumping and sustainable yield; summarizes groundwater quality and reviews potential management elements to be considered by the individual participating agencies. Since that time, the SLDMWA has entered into memoranda of understanding with the City of Patterson and the San Joaquin County Flood Control and Water Conservation District, expanding the coordinated effort. The Plain View Water District has been merged with Byron-Bethany Irrigation District, which participates in the plan for the Plain View service area.

Groundwater management plans need to be living documents that evolve to address legislative and regulatory changes and changing conditions. The GMP-NA is being updated in the present document to reflect the understanding of current conditions in the GMA, summarize the existing groundwater management activities in the Groundwater Management Area (GMA), develop the relative elements of the GMP, identifies management objectives, and provides project recommendations for implementation. and incorporate the appropriate management goals and components necessary to address recent changes that have occurred in regulations, participating agencies' (PAs) policies, and groundwater conditions since the last update. It is intended to establish the framework for collecting the necessary groundwater monitoring data needed to assess the impacts of the various activities that affect the groundwater basin and manage the resource such that sustained use of groundwater can be optimized without adverse impacts to the water quality and yield. Under this plan the PAs, will assume a more active role managing regional groundwater resources within the basin. While PA's will continue to individually adopt the GMP-NA and to develop their own priorities, funding and projects, the Plan provides for additional mechanisms for coordination and cooperation on a regional basis under the umbrella of the SLDMWA. As part of this plan, the SLDMWA will assume the role as the entity responsible for the groundwater monitoring function within the GMA on behalf of the PAs. The groundwater monitoring function will be a cooperative effort of the PAs and the SLDMWA under the SLDMWA's administration.

The water resources utilized in the Northern Agencies (NA) in the Delta-Mendota Canal (DMC) service area of the San Luis & Delta Mendota Water Authority (SLDMWA) support a variety of uses, including industrial, municipal and agricultural application. To supply the various users'

demands, several water sources are utilized within the NA-DMC service area. Water supplies within the NA-DMC service area are obtained from three main sources:

1. Imported surface water diverted from the Sacramento River-San Joaquin River Delta (Delta) and conveyed through the DMC under the Central Valley Project (CVP), and the California Aqueduct (CA) under the State Water Project (SWP). The DMC and CA provide water for urban use in communities, such as the City of Tracy, and for agricultural production. Additionally, treated surface water is imported by the City of Tracy from the South San Joaquin Irrigation District located east of the San Joaquin River.
2. Local surface water supplies diverted from the San Joaquin River for agricultural use.
3. Groundwater for municipal and industrial purposes, rural domestic needs, and agricultural production where the surface water supplies are either not readily available or are insufficient to meet the demand.

Other sources of water supplies occur within the GMA, such as direct precipitation and local stream flows, but these meet a relatively small portion of agricultural water demand and a minor recharge source for groundwater.

As political and environmental conditions change, so does the availability of supplies from these various sources. During drought, the water supply available from the CVP can be limited, which then forces many users to pump groundwater to meet water demand. In addition, CVP water supplies delivered south of the Delta can be limited in an effort to protect endangered species that depend on adequate water conditions within the Delta. During periods when CVP surface water supplies are limited, many water users have had to increase groundwater pumping to augment their supplies to meet demands.

Communities that rely on groundwater have experienced water quality deterioration over time, while regulations governing domestic water quality have become stricter. This combination has made it increasingly difficult for these communities to find groundwater supplies meeting the domestic water quality standards (CCR Title 22, Div. 4, Ch. 15) and has raised serious concerns about the sustainability of groundwater resources to meet domestic demands without treatment. As an example, the City of Tracy uses treated surface water to blend with higher salinity groundwater to provide sufficient potable domestic water to meet the community's water needs.

The growing demand for cost-effective water resources in an ever-changing environment compels the responsible agencies resources to enhance management and to promote long-term stability of this water resource to meet the water needs of the users without depleting the resource. The proper management of groundwater resources requires knowledge of the storage, distribution, depletion, and replenishment of the resource as well as the various local and regional geologic and hydrologic factors. Without such knowledge, the effect of current and future activities on the groundwater resources cannot be adequately predicted.

1.1 Regulatory Basis

In 1992, Assembly Bill 3030 (AB 3030), the Groundwater Management Act, was enacted to amend the California (State) Water Code, Sections 10750 through 10756. It established provisions to allow local water agencies to develop and implement a groundwater management

plan (AB3030 GMP) in groundwater basins defined in the California Department of Water Resources (DWR) Bulletin 118. AB 3030 provided a systematic procedure for existing local agencies to develop AB3030 GMP. Twelve technical components are identified in the Water Code that may be included in an AB3030 GMP. The twelve components consist of the following:

1. The control of saline water intrusion;
2. Identification and management of wellhead protection areas and recharge areas;
3. Regulation of the migration of contaminated groundwater ;
4. The administration of a well abandonment and well destruction program;
5. Mitigation of conditions of overdraft;
6. Replenishment of groundwater extracted by water producers;
7. Monitoring of groundwater levels and storage;
8. Facilitating conjunctive use operations;
9. Identification of well construction policies;
10. The construction and operation by the local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling and extraction projects;
11. The development of relationships with state and federal regulatory agencies; and
12. The review of land use plans and coordination with land use planning agencies to assess activities which create a reasonable risk of groundwater contamination.

An AB3030 GMP can be developed only after a public hearing and adoption of a resolution of intention to adopt a groundwater management plan. The procedures for Adopting an AB 3030 GMP are clearly defined in the Water Code. Once adopted, rules and regulations must be enacted to implement the AB3030 GMP programs. Because there are no explicit provisions regarding amendment or updating GMP programs, it is assumed that updated or amended plans must undergo the same procedural process as the original adoption.

In 2002, Senate Bill SB 1938 was enacted to amend the Water Code Section 10750 *et. seq.* to require that AB 3030 GMPs contain specific elements in order to receive state funding for water projects (DWR, 2010a). This mandates the development of a AB3030 GMP with specific elements, and documented public review if local agencies desire to remain eligible for water grants or loans administered by the State (Water Funds). It also allows for additional elements to be considered in an AB3030 GMP. In order to remain eligible for Water Funds, an agency preparing the AB3030 GMP must include the following:

- a. Documentation that a written statement was provided to the public: “describing the manner in which interested parties may participate in developing the groundwater management plan”, Section 10753.4;
- b. A plan to: “involve other agencies that enables the local agency to work cooperatively with other public entities whose service areas or boundaries overlies the groundwater basin”;
- c. A map showing the area of the groundwater basin, as defined by Bulletin 118, with the area of the local agency subject to the plan as well as the boundaries of the other local entities that overlie the basin in which the agency is developing the AB3030 GMP;
- d. Management Objectives for the groundwater basin subject to the AB3030 GMP;
- e. Components relating to the monitoring and management of the groundwater levels, groundwater quality, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping; and
- f. Monitoring protocols for the components for those components described above (Water code 10753.7 (a)(4)).

In 2008, a draft updated GMP for the NA-DMC service area was prepared as part of the ongoing efforts by the SLDMWA and their PAs to assist in managing the limited water resources in conformance with SB1938 and AB3030. The 2008 draft GMP-NA provided a mechanism to bridge gaps and interface between local PAs' programs to support comprehensive regional water resources management in the GMA. The PA's and the City of Patterson used the SLDMWA umbrella to jointly fund the preparation of a coordinated regional plan. In addition to the NA, portions of San Joaquin County west of the San Joaquin River and outside the boundaries of a local water agency or municipality were included into the GMA. These western outlying portions of San Joaquin County are represented by the San Joaquin County Flood Control and Water Conservation District (SJCFCWCD), which entered into a memorandum of understanding with the SLDMWA such that the GMP-NA could cover this portion of the County. However, the draft plan has not been formally adopted.

Now recent amendments to the Water Code Section 10920 et seq., enacted in 2009 through the passage of Senate Bill SBx7-6, have established further requirements related to groundwater management that have led to this current update to the GMP-NA. SBx7-6 mandates that prescribed entities with authority to assume groundwater monitoring functions (entities) do so, coordinate monitoring efforts with DWR, and convey the information regularly to DWR if they seek to remain eligible for Water Funds (California, 2009). SBX7-6 mandates that (DWR, 2010b):

- Local entities may assume responsibility for monitoring and reporting groundwater elevations;
- DWR work cooperatively with local monitoring entities to achieve monitoring programs that demonstrate seasonal and long-term trends in groundwater elevations;

- DWR accept and review prospective monitoring entity submittals, then determine the designated monitoring entity, notify the monitoring entity and make that information available to the public;
- DWR perform groundwater elevation monitoring in basins where no local party has agreed to perform the monitoring functions; and
- If local entities do not volunteer to perform the groundwater monitoring functions, and DWR assumes those functions, then those entities become ineligible for water grants or loans from the state.

This current update of the GMP-NA addresses these new regulatory requirements set forth in SBx7-6. The GMP-NA designates the local entity that assumes responsibility for groundwater monitoring, and sets forth the framework that will form the basis for a groundwater monitoring program.

1.2 Setting

In general, this GMP-NA is meant to promote groundwater sustainability within the GMA. However, as the individual PAs may have different ambitions they may seek to attain through groundwater management, it would be very difficult to develop or implement highly-specific or locally-specialized groundwater management programs that suit all of the needs of the individual PAs. Rather, at this regional scale, it is more efficient and specific programs would be better focused if they were undertaken by each individual PA or group of PAs depending on their specific local needs. The GMP-NA has been prepared to facilitate coordinated regional management of groundwater resources within the GMA and may not address all of the more specialized or localized groundwater resources management needs that could occur. It is intended that the GMP-NA afford the PAs the operational flexibility to address their own individual or local group needs without being bound by specific programs that are irrelevant to their operations, counterproductive to the cost-effective implementation of local good groundwater management practices or not mandatory for the regional program. Thus, it is anticipated that in some cases the individual PAs may also seek to prepare their own local GMP to augment this regional plan and address specific local needs beyond the more general scope of the GMP-NA. (For example the City of Tracy prepared their own GMP in 2007 that expands on the GMP-NA for a management area encompassing their municipality.) The GMP-NA provides the regional framework for:

- Gathering the groundwater data needed to assess the regional impacts of activities that affect the groundwater resources within the GMA;
- Establishing standards amongst the PAs that promote consistency in management and monitoring practices that provide regional benefits throughout the GMA;
- Interaction of the PAs for regular, early collaborations to discuss and resolve concerns that may arise from groundwater monitoring assessments and projections; and
- Providing general guidance for programs to promote focused groundwater management practices and resource sustainability throughout the GMA for the benefit of the PAs.

Since this is a regional plan, each PA would need to independently adopt the whole plan or portions thereof. Through the appropriate execution of this GMP-NA and sincere efforts of the

PAs, it is anticipated that the sustained use of groundwater within the GMA will be better optimized without adverse impacts to the water quality and yield through the implementation of this GMP. Regional sustainability of the groundwater resources throughout the GMA is the basic goal of this program.

In the past, the PAs within the GMA have engaged in transfers of water supplies to qualified recipients. Under this plan, the PAs will continue to reserve their operational flexibility to engage in such water transfers. However, prior to undertaking any water transfer program, the PAs will evaluate any adverse economic or environmental impacts of the program. The evaluation may include, but is not be limited to, an assessment of management practices, groundwater storage capacity, and conjunctive use with surface water supplies. These programs may be undertaken to assist other areas in need of water, in addition to consumers within the PAs' service areas, and to benefit PAs and their consumers, as long as such programs do not:

- Exceed the safe annual yield of the aquifer;
- Result in conditions of overdraft or otherwise fail to comply with provisions of California Water Code Section 1745.10;
- Result in uncompensated adverse impacts upon landowners affected by the program.

Section 2

The Groundwater Management Area

The DWR divides California into 10 hydrologic regions (HRs), which generally correspond to the State's major drainage areas (DWR, 2003). The HR and the GMA are shown in Figure 1. The San Joaquin River HR was further divided into separate subbasins largely based on political considerations for groundwater management purposes (Figure 2). Figure 2 depicts the groundwater subbasins as described in the DWR Bulletin 118 Update 2003, and the relative location of the GMA boundaries within the subbasins. The GMA lies within the Tracy (5.22-15) and Delta-Mendota (5.22-07) Basins of the San Joaquin River HR, and covers western portions of Merced, Stanislaus and San Joaquin Counties. The GMA is generally bounded:

- on the North by Old River;
- on the west by the Coast Range Mountains, Alamedas County, and those portions of Byron Bethany Irrigation District that lie outside the CVP Service Area;
- on the south by San Luis Water District and Santa Nella Village; and
- on the east by the San Joaquin River and Central California Irrigation District.

The GMA encompasses 173,000 acres. Figure 3 shows the boundaries of the GMA.

The GMA encompasses the following agricultural water supply districts: Banta-Carbona Irrigation District, Westside Irrigation District, West Stanislaus Irrigation District, Patterson Irrigation District, Del Puerto Water District, and the Central Valley Project Service Area (CVPSA) within the Byron-Bethany Irrigation District. Del Puerto Water District includes the former Davis, Foothill, Mustang, Orestimba, Hospital, Kern Canon, Quinto, Romero, Salado, and Sunflower Water Districts. The CVPSA within the Byron-Bethany Irrigation District is the former Plainview Water District. In addition, the GMA encompasses: the City of Tracy (Tracy), the City of Patterson (Patterson), several unincorporated communities, and unincorporated and non-district lands within San Joaquin County represented by the SJFCWCD. A list of the current PAs involved in the GMP-NA is given in Table 1.

Table 1
List of Agencies Participating in the Groundwater Management Plan

-
- San Luis & Delta-Mendota Water Authority (SLDMWA)

Water or Irrigation District:

- Banta-Carbona Irrigation District (BCID)
- Byron-Bethany Irrigation District (only the CVPSA) (BBID)
- Del Puerto Water District (DPWD)
- Patterson Irrigation District (PID)
- West Stanislaus Irrigation District (WSID)
- Westside Irrigation District (WID)

Cities:

- City of Tracy (Tracy)
- City of Patterson (Patterson)

Non-District Lands:

- San Joaquin County Flood Control and Water Conservation District (SJFCWCD)
-

Section 3

Characteristics of the GMA

3.1 Land Use and Groundwater Beneficial Use

Most of the land in the San Joaquin Valley is utilized for agricultural crop production. Major agricultural activities include the operation of dairies, and the production of cotton, tomatoes, beans, alfalfa, corn, grapes, walnuts, almonds and oranges. A number of small rural communities, as well as some large municipalities exist within the San Joaquin Valley. The largest of these communities, Fresno, has a population of nearly a half of a million people. The majority of communities have populations of less than 100,000 people, and many have less than 10,000. Other notable large municipalities in the San Joaquin Valley include Stockton, Modesto, and Bakersfield. The southern end of the San Joaquin Valley also has a large oil production industry, and numerous oil/gas fields are located throughout the San Joaquin Valley.

Within the GMA, the majority of the current land use is agricultural, with irrigated crops, dairies and rangeland. There are two municipalities within the GMA, the cities of Tracy and Patterson, both of which are PAs. Tracy is a municipality with a population of about 80,000 people, and Patterson has a population of about 21,000 people. There are also some smaller unincorporated communities within the GMA.

The beneficial uses of groundwater in the GMA are predominantly for agriculture and related industry, domestic potable water, and other municipal uses. For agricultural applications within the GMA, groundwater is used conjunctively to supplement surface water supplies that support the water needs in the GMA. However, groundwater is the primary source of domestic and municipal water supplies within the GMA. In the case of Tracy, groundwater is supplemented by imported surface water.

3.2 Topography and Structure

The San Joaquin Valley is the southern portion of the Great Valley Geomorphic Province in central California. The San Joaquin Valley is a structural trough up to 200 miles long and 45 to 70 miles wide. It conjoins the northern portion of the Great Valley Geomorphic Province, the Sacramento Valley, at the confluence of the Sacramento and San Joaquin Rivers (“the Delta”). The Great Valley opens to the San Francisco Bay west of the Delta.

The San Joaquin Valley is bounded by the Sierra Nevada Mountains to the east, the Coast Range Mountains to the west, and the Tehachapi Mountains to the south. It is a broad, fault bounded, northwest trending, asymmetric topographic and structural trough, with axis of the valley offset nearer the western margin. The topographic slope along the axis declines gently, generally towards the north-northwest.

Within the GMA, the land surface generally slopes easterly to northeasterly from the base of the Coast Range Mountains, near the western boundary, towards the trough of the valley and the San Joaquin River, along the eastern boundary. Small ephemeral streams drain from the Coast Range

Mountains typically trending northeasterly toward the trough of the valley. The natural land surface is relatively flat to slightly undulating. However, agricultural practices have modified many topographic features to provide suitable conditions for crop production. The land surface elevation in the GMA ranges from about 60-feet above mean sea level in the southwest to about sea level in the north. Major man-made features include Interstate Highway 5, the California Aqueduct, the DMC, and a number of smaller canals used for water supply distribution and drainage.

3.3 Climate

The San Joaquin Valley has a more continental climate than much of the more populous coastal areas, with relatively warm summers and cooler winters. The mean annual high temperatures in the valley range from about 73° Fahrenheit (°F) to 79°F, and the mean annual lows range from about 48°F to 50°F.

Due to some rain shadow effects from the Coast Range Mountains and the lower elevations of the valley floor, the valley experiences relatively little rainfall, typically less than 12 inches. Some areas of the southern San Joaquin Valley experience desert conditions due to the very low seasonal precipitation. Rainfall occurs typically between late fall and early spring, with dry summers. Mean annual rainfall amounts range from 5 to 13 inches per year on the valley floor.

The range of typical climatic conditions experienced within the GMA can vary. Two representative weather stations, with long documented histories, have been chosen to demonstrate the range of climatic conditions within the GMA. The City of Los Banos (Los Banos) lies within 10 miles of the southern boundary of the GMA, and Tracy lies within the GMA near the northern boundary. The recent climatic history recorded for each location is presented below:

- Los Banos:

Between 1906 and 2010, the average annual temperature was 62.2°F, the average monthly high temperature of 96.5°F was in July, and the average monthly low temperature of 36.3°F was in December (WRCC, 2010). Los Banos averages about 97 days per year above 90°F, and 29 days below 32°F. The hottest day on record was 116°F on July 30, 1931, and the coldest was 14°F occurring twice on January 11, 1949 and December 22, 1990.

Between 1906 and 2010, the average annual rainfall was 9.21 inches. The highest annual rainfall was 21.08 inches in 1998, and the lowest annual rainfall was 4.61 inches in 1947. The maximum-recorded rainfall over a 24-hour period was 2.25 inches on September 30, 1983. Annually, Los Banos experiences, on average, about 46 days with precipitation greater than 0.01 inches, 25 days with precipitation greater than 0.10 inches, 5 days with precipitation greater than 0.50 inches, and 1 day with precipitation greater than 1.0 inch.

- Tracy:

Between 1955 and 2010, the average annual temperature was 62.1°F, the average monthly high temperature of 92.7°F was in July, and the average monthly low temperature of 38.3°F was in January (WRCC, 2010). Tracy averages about 75 days per

year above 90°F, and 17 days below 32°F. The hottest day on record was 112°F on June 15, 1961, and the coldest was 17°F on December 26, 1990.

Between 1955 and 2010, the average annual rainfall was 12.07 inches. The highest annual rainfall was 27.48 inches in 1983, and the lowest annual rainfall was 5.44 inches in 1976. The maximum recorded rainfall over a 24-hour period was 2.80 inches on January 4, 1982. On average, annually, Tracy experiences about 55 days with precipitation greater than 0.01 inches, 31 days with precipitation greater than 0.10 inches, 7 days with precipitation greater than 0.50 inches, and 1 day with precipitation greater than 1.0 inch.

Table 2
Summary of Climatic Data for Los Banos and Tracy

		Los Banos	Tracy
Average Monthly High Temperature	°F	96.5	92.7
Average Monthly Low Temperature	°F	36.3	38.3
Hottest Recorded High Temperature	°F	116	112
Coldest Recorded Low Temperature	°F	14	17
Average Number of Days Above 90°F	Day	97	75
Average number of Days Below 32°F	Day	29	17
Average Annual Rainfall	Inch	9.21	12.07
Highest Annual Rainfall	Inch	21.08	27.48
Lowest Annual Rainfall	Inch	4.61	5.44
Maximum 24-hour Rainfall	Inch	2.25	2.80

Based on the climatic data, both Tracy and Los Banos lie within Semi-arid hot climate regimes. While the conditions in Los Banos lie in the middle of the Semi-arid climate regime, Tracy has milder conditions and greater rainfall approaching a more Mediterranean climate regime typical of the Delta. The northern end of the GMA receives on average about 30 percent more rainfall annually than the southern end.

3.4 Geology

The geologic materials that fill the San Joaquin Valley are comprised of mostly unconsolidated alluvial and lacustrine sediments, Holocene to Jurassic in age, derived from parent materials of the Coast Ranges and the Sierra Nevada Mountains. These sediments overlie older marine sediments. The Valley fill reaches a thickness of about 28,000 feet in the southwestern corner (Page, 1986). Continental deposits shed from the surrounding mountains form an alluvial wedge

that thickens from the valley margins toward the axis of the structural trough. This depositional axis is below to slightly west of the series of rivers, lakes, sloughs, and marshes, which mark the current and historic axis of surface drainage in the San Joaquin Valley (DWR, 2003). Major faults run parallel to the western boundary of the GMA, along the east side of the Coast Range Mountains. In particular, the Greenville and Ortigalita faults lie within about 10 to 20 kilometers of the western boundary.

The water bearing geologic formations within the GMA typically are comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include the Tulare Formation, older alluvium, flood basin deposits, terrace deposits, and younger alluvium. The cumulative thickness of these deposits ranges from a few hundred feet near the Coast Range foothills west of the GMA to about 3,000 feet along the trough of the valley east of the GMA (DWR, 2003).

The Tulare Formation is composed of beds, lenses, and tongues of clay, sand, and gravel that have been alternately deposited in oxidizing and reducing environments (Hotchkiss, 1972). The Tulare Formation dips eastward from the Coast Ranges in the west towards the trough of the valley east of the GMA. The total thickness of the Tulare Formation is about 1,400 feet (DWR, 2006). The Corcoran Clay occurs near the top of the Tulare Formation and confines the underlying fresh water deposits.

3.4.1 Confined Aquifer

The confined aquifer zone underlying the Corcoran clay stratum extends downward from the base of the clay to the base of fresh water (Page, 1971). Sierran Sand and Coast Ranges alluvium interfinger in a similar fashion as those of the semi-confined zone above, except that Sierran sediments extend further to the west in the confined zone (Dubrovsky et al., 1991).

3.4.2 Corcoran Clay Layer

Much of the central and northern portions of the valley, which includes the GMA, is underlain by a continuous aquitard layer of Pleistocene age, known as the Corcoran Clay layer or E-clay. This layer is comprised of fine-grained lacustrine and marsh deposits that divide the aquifer system vertically into an upper semiconfined zone and a lower confined zone (Davis and DeWiest, 1966). Because of this, the underlying aquifer is typically designated the confined aquifer or zone in the regions where the Corcoran Clay occurs. The Corcoran Clay member of the formation underlies the basin at depths ranging from about 100 to 500 feet and acts as a confining bed (DWR 1981). The unconsolidated sediments of the valley floor taper toward the Coast Ranges, and the Corcoran Clay becomes discontinuous along the west margin of the valley, near the western limits of the GMA.

3.4.3 Semiconfined Aquifer

Overlying the Corcoran Clay is the semiconfined zone. It is comprised of sediments derived from the Coast Ranges on the west interfingered to the east with sediments derived from the Sierra Nevada. These sediments comprise the older alluvium, younger alluvium and terrace deposit layers. The Coast Range and Sierran sediments differ in their hydrogeologic characteristics. The Coast Range sediments consist of beds, lenses, and tongues of clay, sand,

and gravel, and form most of the sedimentary material deposited west of the San Joaquin River (Hotchkiss, 1972). Although there are no distinct continuous aquifers or aquitards within the Coast Range alluvium, the term “semiconfined” is used to emphasize the cumulative effect of the vertically distributed fine-grained materials. The Sierran sediment that interfingers with the Coast Range alluvium is well sorted, medium to coarse-grained micaceous sand derived from the Sierra Nevada. The uppermost expression of the interface between the Coast Ranges and Sierran deposits is close to the eastern boundary of the GMA.

Across much of the San Joaquin Basin, a layer of older alluvium consisting of loosely to moderately compacted sand, silt and gravel deposited in alluvial fans during the Pliocene and Pleistocene ages overlies the Tulare Formation. The older alluvium is widely exposed between the Coast Range foothills and the Delta. The thickness of the older alluvium is up to about 150 feet. It is moderately to locally highly permeable.

A layer of younger alluvium overlies the layer of older alluvium. This layer includes sediments deposited in the channels of active streams as well as overbank deposits and terraces of those streams. They consist of unconsolidated silt, fine to medium grained sand, and gravel. Sand and gravel zones in the younger alluvium are highly permeable and, where saturated, yield significant quantities of water to wells. The thickness of the younger alluvium near Tracy is less than 100 feet (DWR, 2006). Further south, terrace deposits of Pleistocene age are up to several feet higher than present streambeds. They are composed of yellow, tan, and light-to-dark brown silt, sand, and gravel with a matrix that varies from sand to clay (Hotchkiss 1971). The water table generally lies below the bottom of the terrace deposits.

In the northern portion of the GMA, flood basin deposits occur (DWR, 2006). They are the distal equivalents of the Tulare Formation and older and younger alluvial units and consist primarily of silts and clays. Occasional interbeds of gravel occur along the present waterways. Because of their fine-grained nature, the flood basin deposits have low permeability and generally yield low quantities of water to wells. The flood basin deposits are generally composed of light-to-dark brown and gray clay, silt, sand, and organic materials with locally high concentrations of salts and alkali. Occasional zones of fresh water are found in the basin deposits, but they generally contain poor quality groundwater. The maximum thickness of the flood basin deposits is about 1,400 feet.

3.5 Hydrology

The following sections discuss the surface and groundwater hydrology of the area. Hydrologically, the GMA has inflow from outside bringing water supplies into the area.

Sources of inflow into the GMA include:

- diversions into the GMA from the San Joaquin River,
- the streams and channels conveying storm runoff from the east side of the Coast Range Mountains,
- the network of canals conveying surface water south from the Delta,
- subsurface groundwater flowing in from the southwest,
- and precipitation.

Sources of outflow from the GMA include:

- surface runoff to the San Joaquin River,
- groundwater flow moving towards the trough of the valley and exiting the GMA,
- groundwater discharged to the San Joaquin River system, directly or through subsurface drainage systems in some areas,
- evaporation,
- Surface waters conveyed out of the GMA by canals and drainage ways,
- and crop and phreatophyte evapotranspiration.

3.5.1 Surface Hydrology

Streams that drain into the northern two-thirds of the San Joaquin Valley, flowing from the Sierra Nevada and Coast Range mountains, empty into the San Joaquin River and flow northward to join the Delta. Historically, the rivers and streams in the southern one-third of the San Joaquin Valley had no natural drainage connecting to the ocean, but rather drained into Tulare and Buena Vista Lakes. Seasonal flooding would occur along these rivers and streams in spring as rainfall and snowmelt from the mountains drained to the valley floor. A number of dams placed along the major watercourses, particularly in the Sierra Nevada Mountains, have alleviated the flooding. The majority of the runoff that drains into the San Joaquin River is derived from the rainfall and snowmelt from the western side of the Sierra Nevada Mountains. These rivers typically drain southwest to west out of the Sierra Nevada Mountains, turning north at the trough of the valley floor, where the San Joaquin River is located.

The ephemeral streams of the eastern side of the Coast Range Mountains typically drain east to northeast out of the mountains towards the trough of the valley floor. Many of these streams only flow during torrential winter storms and for very short periods following. In the past, many of these ephemeral streams would drain out onto the valley into wetlands and infiltrate before reaching the San Joaquin River. This infiltrated water would supply base flow for the San Joaquin River and recharge groundwater. Many of these ephemeral streams have been transected by canals and highways, their drainage courses diverted, and agriculture reclaimed and drained much of the wetlands and lakes. Much of the surface hydrology of the San Joaquin Valley is controlled by man-made structures and practices. Surface waters in the San Joaquin Valley are frequently conveyed into and out of the valley by a network of large canals that supply users' needs in areas far from the natural source. Large man-made reservoirs are used to retain and store runoff from the mountains and temporary surface water being conveyed to other locations.

Consistent with most of the San Joaquin Valley, within the GMA, much of the surface hydrology is governed by the man-made structures, agricultural practices, and urbanization. A notable few ephemeral streams convey water into the GMA from the east side of the Coast Range Mountains.

These streams include:

- Corral Hollow Creek,
- Lone Tree Creek,
- Hospital Creek,

- Ingram Creek,
- Del Puerto Creek,
- Crow Creek,
- Salado Creek,
- Orestimba Creek,
- and Garzas Creek.

North of Tracy, a network of sloughs and river channels, including the Old River and Middle River, intertwine as the San Joaquin River system and nearby streams forming a part of the Delta. Some areas within the GMA are relatively flat, and groundwater can be seasonally shallow. The San Joaquin River flows along the eastern boundary of the GMA and is a major source of water to the GMA.

Besides the natural water conveyance systems, major canals convey water from the Delta, to and through the GMA. These canals include the California Aqueduct and the DMC. Other smaller canals in the network convey surface water from the San Joaquin River and the CVP to the users, and drain runoff from areas within the GMA. The DMC is a major water supply source to the GMA.

3.5.2 Subsurface Hydrology

Groundwater in the region occurs in three water-bearing zones (DWR, 2006). These include the lower zone, which contains confined fresh water in the lower section of the Tulare Formation, an upper zone which contains confined, semi-confined, and unconfined water in the upper section of the Tulare Formation and younger deposits, and a shallow zone which contains semi-confined and unconfined water to within about 25 feet of the land surface.

Agricultural irrigation in the GMA provides most of the recharge water of the upper semiconfined zone through seepage losses occurring in irrigation water conveyance channels and by deep percolation of applied water. Other sources of recharge include seepage from creeks and rainfall. Occasional recharge from the creeks that enter the GMA from the Coast Ranges to the west is relatively small compared to the other sources (KJC, 1990). Recharge to the lower confined zone occurs primarily by infiltration downward from the unconfined zone through the Corcoran Clay. Groundwater pumping from below the Corcoran Clay in the GMA is likely to increase percolation through the clay layer.

Historically, groundwater flow was northwestward parallel to the San Joaquin River (Hotchkiss and Balding, 1971). The groundwater flow direction towards the San Joaquin River typically causes subsurface outflow laterally along the eastern boundary of the GMA. The hydraulic gradients west of the San Joaquin River are generally steeper than gradients east of the river (Phillips, et al., 1991). Typically, notwithstanding local influences, the water table west of the San Joaquin River can be thought of as a subdued replica of the ground surface topography, sloping gently toward the river from the Coast Ranges. More recent data shows flow tending northeastward, toward the San Joaquin River (DWR 2003). Potentiometric surface maps, developed from DWR water surface elevation measurements for wells screened in the unconfined aquifer, for the Spring of 2004 and Spring of 2008 show the general subsurface flow direction and gradients throughout the GMA during these periods (Figure 4 and Figure 5). The

flow directions appear to continue to be generally consistent with the northeasterly trend towards the San Joaquin River, as noted above, with some localized variations for well pumping depressions and various minor physiographic features that effect drainage and recharge.

The previous GMP (Stoddard & Associates, 1996) indicated that the average groundwater levels from 1986 through 1993 have declined in the subbasins, but from 1993 through 1994, water levels rose throughout the study area, demonstrating recovery in the groundwater storage system. That report concluded that the study area was in a hydrologically balanced condition over the study period.

As a part of this planning effort, changes in groundwater levels in the upper zone were examined over the 1993 to 2008 period. From Spring 1993 through Spring 1998, the groundwater levels continued to rise throughout most of the GMA (Figure 6). This pattern reversed during the Spring 1998 to Spring 2004 period (Figure 7). From Spring 2004 through Spring 2008, the groundwater levels recovered slightly throughout most of the GMA, with localized areas where water levels continued to decline west of the City of Newman, and northeast of Tracy (Figure 8). Longer-term trends in the groundwater levels can be observed in the figures showing change in groundwater levels from 1993 through 2008, and 1998 through 2008 (Figure 9 and Figure 10). Over these longer time frames the groundwater levels appeared to be generally hydrologically balanced across much of the GMA throughout the study period, with local areas of consistent decline persisting west of Newman and in the area of Tracy. The change in groundwater levels in the northern part of the subbasin (Tracy to Westley) appears to show a consistent decline in groundwater levels. This decline could be indicative of a developing overdraft condition in that area.

The groundwater levels underlying the vicinity of Patterson appeared to have minimal net change and appeared generally hydrologically balanced through the study period. The DWR groundwater database utilized a number of different wells for groundwater level measurements between 1993 and 2008 for the central part of the GMA (West Stanislaus ID and Patterson ID). Data from close-by monitoring wells was used to calculate groundwater level elevation changes when there was no other information available. For this reason, some actual local elevation changes may differ slightly from those depicted on the groundwater elevation change maps. The minimal apparent net change in groundwater level elevation seems to indicate equilibrium within the GMA between recharge and use during the study period. The change in groundwater levels in the southern part of the subbasin (West of Newman) also appears to show a consistent decline in groundwater levels. This decline could also be indicative of a developing overdraft condition in that area. However, further south in the Merced County portions of the GMA (West of Ingomar), the long-term change in groundwater levels appears to indicate this area is generally hydrologically balanced.

3.6 Groundwater Quality

Between March and July 1985, the United States Geologic Society (USGS) analyzed water samples from 44 wells in the northern part of western San Joaquin Valley (Dubrovsky, et al., 1991). The objective was to assess the geochemical relations and distribution of major ions and selected trace element concentrations in groundwater of the area. Their results indicate a relatively better quality of water in the confined zone than in the semiconfined zone. These results were supportive of those of Hotchkiss and Balding (1971). Concentrations of selected

constituents reported by USGS (Dubrovsky, et al., 1991) in both zones are provided in Table 3. It was concluded that the areal and vertical distributions of groundwater of varying quality has been affected by different agricultural and natural sources of recharge, and the sources and geochemical nature of the sediments are products of a depositional environment.

Table 3
Chemical Analysis of Selected Constituents in Groundwater

State Well No.	Sampling Date	Sulfate	Upper Zone	N	Boron	As (µg/L)	Se
			TDS (mg/L)				
2S/5E-13P1	3/28/85	320	1400	9.1	2.20	<1	4
3S/6E-07E1	3/11/85	230	1100	6.4	1.60	1	2
4S/7E-33B1	3/12/85	370	1400	0.1	0.90	3	10
5S/7E-01M2	5/01/85	120	750	18.0	0.58	<1	2
5S/8E-22C1	4/30/85	1200	2400	0.9	2.20	3	13
6S/8E-04P1	5/16/85	540	1300	15.0	0.51	<1	4
7S/8E-13N1	3/26/85	300	1900	11.0	0.64	<1	<1
8S/8E-01H1	3/27/85	120	750	11.0	0.48	<1	2

State Well No.	Sampling Date	Sulfate	Lower Zone	N	Boron	As (µg/L)	Se
			TDS (mg/L)				
2S/5E-21D1	3/27/85	220	650	2.3	1.30	1	3
2S/6E-20L2	5/21/85	140	510	<0.1	0.57	5	<1
3S/5E-20A2	3/28/85	330	920	1.4	3.00	<1	2
3S/6E-26Q1	3/12/85	120	710	5.6	0.79	<1	1
4S/6E-09M1	3/13/85	44	340	9.1	0.43	<1	2
4S/7E-36Q3	3/13/85	120	690	8.3	0.59	<1	1
5S/7E-27B1	5/16/85	190	760	16.0	1.20	1	5
5S/8E-32K3	4/30/85	530	1000	4.0	0.67	1	11
6S/7E-01R1	5/16/85	630	1300	9.6	0.86	1	6
6S/8E-03R2	5/16/85	360	820	6.4	0.41	2	8
7S/8E-27Q1	5/13/85	56	650	10.0	0.47	<1	<1

More recently USGS, in cooperation with DWR, has undertaken a comprehensive study of the groundwater resources within California called the Groundwater Ambient Monitoring and Assessment (GAMA) Program. The GAMA program collects groundwater data for numerous chemical constituents of the water from numerous wells throughout the various groundwater basins within the State. Currently, within the GMA only the initial study of the Northern San Joaquin Study Unit has been published (Faunt, C.C., ed., 2009). This Study Unit consists of four subbasins defined in Bulletin 118 including the Tracy subbasin in western San Joaquin County. The results of that study are presented in the attached Appendix A. The remainder of the GMA lies within the Western San Joaquin Valley Study Unit, which consist of the Delta Mendota subbasin and the Westside subbasin. Publication of initial study of the Western San Joaquin Valley Study Unit is pending and should be available later in 2011.

3.6.1 Hydrochemical Facies

Chemical analyses of groundwater from the semiconfined zone show considerable variation in water type and concentration of dissolved solids (Hotchkiss and Balding, 1971). In general, the chemical character of the water in the upper water bearing zone (except near Patterson and Crows Landing) is a transitional type, i.e., groundwater in which no single anion or cation reacting value amounts to 50 percent or more of the total reacting values. The transitional type groundwater in the GMA occurs in many combinations.

Groundwater near Tracy is very hard. Northwest of Tracy, in the vicinity of the Jones Pumping Plant, groundwater is a chloride type. The sodium chloride type groundwater in the area northwest of Tracy is probably due to infiltration of water from Old River. Old River water varies from transitional chloride bicarbonate to sodium chloride type (Hotchkiss and Balding, 1971).

Sulfate type groundwater occurs in areas located west of Patterson and Crows Landing. Near Patterson, groundwater is sodium magnesium sulfate type to the west and sodium calcium sulfate type to the east. Waring (1915) mentioned some small sulfur springs on Crow and Orestimba Creeks, indicative of sulfate bearing deposits that are probably responsible for the sulfate groundwater type in the area near Patterson (Hotchkiss and Balding, 1971).

3.6.2 Dissolved Solids

Results of the USGS sampling study showed that in the semi-confined zone the total dissolved solids (TDS) concentration ranges from 750 to 2,400 mg/L. Areal distribution of the data shows a high TDS concentration (>1,500 mg/L) in groundwater in the semiconfined zone measured near Patterson and west of Newman, and low concentration (<1,000 mg/L) is reported near the community of Westley. The TDS concentration in water in the confined zone generally ranged between 500 and 1,000 mg/L. Although high TDS concentrations (>1,000 mg/L) in water in the confined zone have been reported southwest of Patterson by the USGS, Patterson has reported TDS concentrations between 600 and 1,000 mg/L (Patterson, 2004). The distribution of TDS in groundwater in the two zones shows little similarity, with the deeper zone showing relatively low TDS, and shallower zone showing almost consistently high TDS.

3.6.3 Sulfate

Sulfate concentrations vary greatly in both water-bearing zones, but areal distribution is similar in both zones. Highest sulfate concentration in groundwater (>500 mg/L) is measured in an area centered near Crows Landing and Patterson. A similar area of high sulfate concentration was also reported by Hotchkiss and Balding (1971) and is likely related to the Coast Range streams that recharge this area (Hotchkiss and Balding, 1971). Smaller sulfate concentrations were reported in 2004 by Patterson, which detected concentrations in a range between 190 and 380 mg/L (Patterson, 2004). In 2004, Tracy reported groundwater sulfate concentrations between 160 and 330 mg/L (Tracy, 2004). The lowest concentrations of sulfate in groundwater (<100 mg/L) were measured in an area south of Vernalis. The similarity of sulfate concentrations in the GMA could result from the presence of similar sulfate concentrations in the streams that were the major source of recharge under natural conditions over a long period of time.

3.6.4 Boron

Concentrations of boron in groundwater range from 0.48 to 2.2 mg/L in the semiconfined zone and from 0.41 to 3.0 mg/L in the confined zone. Areal distribution of boron in the semiconfined zone shows high concentrations (>0.75 mg/L) near Tracy and northeast of Crows Landing near Patterson. The areal distribution of boron in the confined zone shows high boron concentrations (>0.75 mg/L) near Tracy, Vernalis and west of Patterson. This agrees with the results presented by Tracy (Tracy, 2004). The U.S. Environmental Protection Agency (EPA) suggested criterion for boron concentration in water used for long-term irrigation of sensitive crops is 0.75 mg/L. This limit was exceeded in four samples in the semiconfined zone and five samples in the confined zone (Table 3).

3.6.5 Arsenic

Recently, the federal primary drinking water standard maximum contaminant level (MCL) for arsenic was lowered from 50 µg/L to 10 µg/L. This change became effective for all states as of January 23, 2006, and California's revised arsenic MCL of 0.010 mg/L (equivalent to 10 micrograms per liter, µg/L) became effective on November 28, 2008 (DPH, 2008). Currently, the California standard is consistent with the federal standard. Arsenic is typically derived by dissolution of igneous parent materials, and released from iron and manganese oxides when pH declines. Based on the USGS study, arsenic concentrations in the groundwater samples from the semi-confined aquifer in the GMA vicinity ranged between 1 and 38 µg/L, which at that time were below the MCL (Dubrovsky, et al, 1991). Based on the USGS study, arsenic concentrations in the groundwater samples from the confined aquifer in the region ranged between 1 and 18 µg/L. Within the GMA the highest reported arsenic concentrations were 3 µg/L and 5 µg/L, respectively. In both aquifers, arsenic concentrations were reported that exceeded the current MCL in the vicinity of the GMA, but none within the GMA. The arsenic distribution between the groundwater in the semi-confined and confined aquifers showed little difference. However, the areal distribution showed an increase in arsenic concentrations in the GMA toward the southeast. The concentrations increased in the Sierran sediments. The increase is probably related to the higher proportion of Sierra sediments in the profile towards the southeast. In their respective water quality reports, Tracy reported arsenic concentrations as high as 3 µg/L, and Patterson reported arsenic concentrations as high as 6 µg/L, which are below the current MCL (Tracy, 2004; Patterson, 2004).

3.6.6 Selenium

Selenium concentrations in the GMA groundwater range from a less than detectable limit of 1 µg/L to 13 µg/L (Table 3). The current MCL for selenium in drinking water is 50 µg/L. The selenium MCL concentration was equaled or exceeded in two samples from the unconfined zone and in one sample from the confined zone. The concentration and areal distribution of selenium were similar in both zones. Selenium concentrations are relatively high (10 µg/L) in a narrow area of both zones between Patterson and Crows Landing. Lower concentrations (between 3 and 8 µg/L) were reported in 2004 by Patterson (Patterson, 2004). However, higher concentrations (non-detect to 10 µg/L) were reported in 2009, consistent with the range shown in Table 3 (Patterson, 2009). In the Tracy and Vernalis area, the selenium concentrations range between 1

µg/L to 5 µg/L. The USGS (Dubrovsky, et al., 1991) study concluded that selenium was transported to the area under natural conditions by runoff from the Coast Range.

3.6.7 Nitrate

The MCL for nitrate in drinking water is 45 mg/L. The USGS (Dubrovsky, et al., 1991) sampling study indicated that no well water in the GMA exceeds the MCL for nitrate. This agrees with the results presented by Tracy (Tracy, 2009). However, Dubrovsky et al (1991) mentioned that there were reports of nitrate MCL exceedance in shallow domestic wells. In general, higher nitrate concentrations in groundwater exist along the west side of the GMA and in the Westley area. The areas along the San Joaquin River have lower nitrate concentrations (Hotchkiss and Balding, 1971).

Within both the Tracy and Patterson areas, the quality of the municipal potable water supply is routinely monitored as required by State law. Historical data provided by Patterson for municipal supply wells shows a possible long term trend of increasing nitrate concentrations in some wells, Wells 4, 6 and 8, (Patterson, 2010). These wells tend to be located in the western portion of the distribution network for the City. Well No. 4 had to be removed from operation recently, in 2007, due to continued exceedance of the primary MCL. Upon entering service, nitrate concentrations in Well No. 4 were near the MCL and had remained marginal with water quality frequently at or near the MCL and a few occurrences where sample results had exceeded the MCL during this period of operation. All other wells in operation in Patterson remain viable and show no signs of an increasing trend in nitrate concentrations.

3.6.8 Trace Elements

The Deverel et al. (1984) study (reported by Dubrovsky, et al., 1991) states that the shallow groundwater, near the top of the semiconfined zone and less than 30-feet below the land surface, generally has higher trace element concentrations than the deeper zones. This study indicates that the higher trace element concentrations in the shallow groundwater might correlate with the generally higher TDS concentrations in the shallow groundwater. The higher concentrations probably result from leaching of soil salts and evaporative concentration of shallow groundwater near the land surface.

Because of the high variability of groundwater quality in the GMA, focused groundwater supply investigations are necessary to determine if groundwater is suitable for an intended use. Additionally, management practices must be designed and implemented to maintain or improve groundwater quality to meet the differing needs of the users within the GMA.

Section 4

Management Objectives

As it was stated before, typically, this regional program will rely on the PAs to develop the specific program components to meet management objectives that address local groundwater concerns while considering regional interests.

There are general objectives that should be considered for management of groundwater resources within the GMA:

- Assure an affordable groundwater supply for the long term needs of the users.
- Prevent long-term depletion of groundwater resources and maintain adequate groundwater supplies for all users.
- Maintain groundwater quality to meet the long-term needs of users.
- Attempt to reduce or prevent inelastic land subsidence due to groundwater overdraft.
- Maintain general continuity between groundwater management practices and activities undertaken by the PAs.

Section 5

Program Components Relating to Management

5.1 Components Relating to Groundwater Level Management

Groundwater level management is becoming more critical to protect against future problems related to groundwater overdraft. Overdraft is the condition of a groundwater basin in which the amount of water withdrawn by pumping over the long term exceeds the amount of water that recharges the basin (DWR, 2003). Overdraft can lead to shortages in supplies, increased extraction costs, land subsidence, water quality degradation, and environmental impacts. With increasing demands for water supply, the ability to accurately quantify and manage groundwater resources is imperative to maintaining a sustainable resource.

5.1.1 Reduction of Groundwater Use by Development of New Surface Water Supplies

Agencies buy water from out-of-basin sellers to supplement their supplies.

Activities within the GMA: Tracy is participating with the cities of Manteca, Lathrop, Escalon and the South San Joaquin Irrigation District in the South County Surface Water Supply Project (SCSWSP), which brings high quality Sierra Nevada water from the Stanislaus River to cities for their urban use. The project reduces the reliance on groundwater while satisfying urban demands. A water treatment plant on the Stanislaus River uses water that the irrigation district has conserved from improvements in irrigation practices and water use efficiencies. Water from South San Joaquin Irrigation District is conveyed through Woodward Reservoir, treated to drinking standards, and conveyed to Tracy. Water deliveries commenced in July 2005, and Tracy has been importing approximately 10,000 acre-feet of water a year through this source. During those years where CVP allocations are significantly lower than normal, the PAs purchase surface water from water suppliers north of the Delta in addition to using more of the local groundwater resource.

5.1.2 Increase Use of Available Surface Water Supplies

There are some in-basin water transfers and purchases from agencies to others with limited surface water rights and groundwater resources.

Activities within the GMA: Surface water is purchased by Tracy from West Side Irrigation District and Banta Carbona Irrigation District. Tracy has developed agreements with Byron-Bethany Irrigation District to purchase additional water in the future from their CVP water supply for Tracy's municipal and industrial uses.

5.1.3 Development of Overdraft Mitigation Programs

According to the DWR definition, overdraft occurs when continuation of present water management practices would probably result in significant adverse overdraft related impact upon

environmental, social, or economic conditions at a local, regional, or state level. Long-term depletion of storage can cause several problems, including land subsidence, degradation of groundwater quality, and increased pumping costs.

Although overdraft of the entire basin is not occurring, conditions of localized overdraft could happen, since areas of extraction do not typically coincide with areas of recharge. One portion of the GMA can experience an increase in groundwater storage while another shows a continual decrease. Such localized overdraft can cause the same adverse impact as basin-wide overdraft, except on a smaller scale. Monitoring of groundwater levels and water quality is necessary to identify areas where localized overdraft is occurring, and to evaluate its effect. The monitoring will allow the overdraft to be quantified, which is needed to evaluate means to control or reverse the overdraft. Curtailing local overdraft usually requires increasing or redistribution of basin surface water supplies or reducing the amount of groundwater pumped.

The prerequisite to implementation of an overdraft mitigation program is to monitor groundwater levels. Once groundwater trends are known, a responsive overdraft investigation program should be developed around the following components:

- Identify areas of overdraft.
- Determine the potential for significant adverse impact due to the overdraft.
- Formulate a plan to mitigate the impact and a strategy for plan implementation.

Activities within the GMA:

- a. Activities in the GMA to address overdraft mitigation programs include those programs described in 5.1.1 and 5.1.2 above.
- b. Del Puerto Water District has implemented policies to restrict the pumping and transfer of groundwater outside the area where the pumping occurs, and to restrict pumping for transfer where such groundwater extraction may damage adjacent land owners or cause overdraft conditions to develop.
- c. SLDMWA through USBR has contracted the USGS to modify the USGS Central Valley Hydrologic Model (CVHM) to provide a potential for increased resolution in the model within the GMA, as well as other areas serviced by SLDMWA. It is intended that this higher resolution CVHM will be accessible to PAs to employ in evaluating the potential for changing groundwater conditions under selected potential water management schemes.
- d. Increased groundwater monitoring within the GMA

5.1.4 Development of Conjunctive Use Programs and Projects

Conjunctive use of groundwater and surface water typically occurs when the surface water supply varies from year to year and is insufficient at times to meet an area's demand. In some years, the surface water supply is greater than the water demand; and in other years, the surface water supply cannot meet the entire water demand. In the years when water is plentiful, water available above the demand is utilized to recharge the groundwater aquifer. Recharge can occur

either directly by operation of recharge facilities or injection wells, or indirectly, by applying surface water where available to areas to avoid the pumping and use of groundwater. In effect, the groundwater basin is utilized as a storage reservoir, and water is placed in the reservoir during wet periods and withdrawn from the reservoir during dry periods.

There are opportunities for conjunctive use in the study area that could increase overall water supply yield; however, each must be evaluated in terms of available water supply, basin geology, available storage capacity, pumping zones, and recharge potential to determine yield, costs, and potential adverse impacts. In the GMA, pumping takes place primarily from the confined zone, while unoccupied aquifer storage is currently available only in the unconfined zone. Based on the basin characteristics, water supply sources, and current groundwater usage, potential conjunctive use opportunities should focus on the following:

- Identifying areas of local overdraft and evaluating the viability of a recharge program using direct recharge.
- Evaluating the availability of additional surface water supplies, which could be utilized in conjunctive use programs either directly or via exchange of CVP supplies.
- Optimizing the overall groundwater yields during dry periods through sound basin management.

In recent history in the GMA, conjunctive use has been practiced in an unmanaged fashion. When full CVP water supplies are being received, relatively little pumping occurs and recharge occurs through seepage and deep percolation of surface water. During water short periods, water is withdrawn from the aquifer to make up for the deficits in surface water supply. Increased pumping due to chronic surface water shortages are causing more emphasis to be placed on locating water supplies for groundwater recharge.

Activities within the GMA: Patterson Irrigation District pumps groundwater on an as needed basis. The District has focused its efforts on improving surface water delivery and pumping efficiencies by recycling surface drainage as opposed to limiting canal seepage. Deep percolation of irrigation water and distribution system seepage losses, recharge the groundwater. The stored groundwater supply is available to the District and others during drought conditions. Such recharge is an important component to the District's water management strategy (Patterson ID, 2005). DWR has implemented, through its Conjunctive Water Management Program (CWMP), several integrated programs to improve the management of groundwater resources in California. The program emphasis is on forming partnerships with local agencies and stakeholders to share technical data and costs for planning and developing locally controlled and managed conjunctive water use projects. DWR and SJCFCWCD entered into a Memorandum of Understanding to cooperatively develop a CWMP, establish an advisory committee representative of all water stakeholders, and complete a basin management evaluation (DWR, 2006).

Tracy has acquired permits from the Central Valley Regional Water Quality Control Board (RWQCB) to proceed with an Aquifer Storage and Recovery (ASR) program. The ASR program will utilize the local groundwater aquifer for long term water storage of available surface water, as a way to increase the reliability of Tracy's water supply. They have received authorization to proceed with pilot testing and have proceeded through the 3rd cycle of a 4-cycle

pilot testing program. The proposed project would consist of injecting surface water treated to drinking water standards into the aquifer via deep wells during times of surplus water and recovery of the water from the aquifer to optimize delivered water quality and meet demands during droughts or when emergency or disaster scenarios preclude the use of imported water supplies. Tracy anticipates that the ASR program will be capable of storing approximately 9,000 af of high-quality surface water allowing for on average 3,000 af of stored water to be available in drought years, thereby increasing the reliability of Tracy's water supply and closing the potential future gap between supply and demand during drought or emergency conditions through 2025 (EKI, 2005).

Tracy is also studying the possibility of procuring surface water storage to increase water supply reliability. Tracy is evaluating the potential to buy water storage capacity in the Semitropic Water Banking Project (Semitropic) in Kern County. To store water in Semitropic, Tracy would transfer a portion of its CVP water from the DMC through the California Aqueduct for delivery to Semitropic. During a drought, Semitropic would pump the stored water into the California Aqueduct and a like amount of water would be made available to Tracy to pump from the DMC. Tracy negotiated with Semitropic to purchase up to 10,500 af of storage volume. If this storage were filled, it would provide Tracy with up to 3,500 af of water annually for three years during water short periods (EKI, 2005).

Patterson is in the process of updating its General Plan and has prepared a Final Environmental Impact Report (FEIR) on the update (Patterson, 2010). This FEIR includes new policies oriented towards implementing conjunctive use of recycled water and imported surface water supplies to augment the City's supplies through application to landscape irrigation and other non-potable municipal uses providing "in-lieu" groundwater recharge.

5.1.5 Development of Agricultural and Urban Incentive Based Conservation

Increasing water use efficiency, either urban or agricultural, should be an important component of the long-term planning and management of water resources. It makes prudent use of the available supplies, helps compensate chronic reductions in supply from competing demands and in some cases may reduce the need for developing new water supplies.

The experience of active urban water conservation programs in California is that the potential for water savings are initially about 10 to 20 percent of the volume of water used. Such programs typically include distribution system leak-reduction programs, household metering, tiered pricing to discourage inefficient use, education of the public on water savings measures and market-enforced transition to water-saving household plumbing devices.

The greatest potential for agricultural water conservation relies mainly on the use of more efficient irrigation technologies and irrigation scheduling based on crop water needs. Increasing irrigation efficiency decreases the amount of water that is lost to the system or leaves the site through surface water runoff or deep percolation to groundwater.

In November 2009, SBx7-7 was enacted. It requires all water suppliers to increase water use efficiency and utilize a single standardized water use reporting form, which would be used by both urban and agricultural water agencies. It sets a goal for urban water users of reducing per capita urban water use by 20% by December 31, 2020. Agricultural water suppliers must

prepare and adopt agricultural water management plans by December 31, 2012, updating those plans by December 31, 2015 and every 5 years thereafter. In addition, On or before July 31, 2012, agricultural water suppliers shall:

- Measure the volume of water delivered to customers. The Department of Water Resources shall adopt regulations that provide for a range of options that agricultural water suppliers may use to comply with the measurement requirement.
- Adopt a pricing structure for water customers based at least in part on quantity delivered.
- Implement additional efficient management practices.

CVP contractors that maintain and regularly update the water management plans required by federal law and regulations comply with these requirements. Agencies that fail to comply with SBx7-7 would be ineligible for State Water funds.

Activities within the GMA:

- a. Tracy developed a Water Conservation Plan in 2000. This plan was subsequently updated in 2009 and is currently under review by the United States Bureau of Reclamation for approval. The conservation efforts include implementation of the California Urban Water Conservation Council's (CUWCC) 14 Best Management Practices (BMPs). The BMPs include residential water surveys, system water audits and leak detection, water pricing to encourage conservation, waste prohibitions, public information, landscape guidelines, etc.

An update of the Urban Water Management Plan (UWMP) for Tracy was prepared in 2005 to fulfill the UWMP Act requirements. This UWMP describes how Tracy intends to manage its current and future water resources and demands to continue to provide its customers with an adequate and reliable water supply. This updated UWMP reflects changes to the Tracy's water supply portfolio and water demands since 2000 (EKI, 2005). Currently, a new update of the UWMP is scheduled for 2011.

The PAs that utilize agricultural water supplies of CVP water have completed agricultural water management plans and periodically update the plans pursuant to the Reclamation Reform Act of 1982 and the Central Valley Project Improvement Act (CVPIA). In these plans, water conservation practices have been identified and instituted to maximize beneficial use of the water supply. Practices include better irrigation management, physical improvements, and institutional adjustments. Irrigation management practices include on-farm water management and district water accounting, use of efficient irrigation methods, and on-farm irrigation system evaluations. Physical improvements include lining of canals, replacement of unlined ditches with pipeline conveyance systems, and improvement of on-farm irrigation and drainage technology. Institutional adjustments include improvements in communication and cooperative work among districts, water users, and state and federal agencies, increased conjunctive use of groundwater and surface water, and facilitating the financing of on-farm capital improvements. Other practices that have been instituted include installation of flow measuring devices, modification of distribution facilities to increase the flexibility of water deliveries, and changes in the water fee structure to provide incentive for more efficient use of water. The water management plans have helped the districts identify and implement policies and projects for better irrigation water

utilization. Compliance with CVPIA water management plans will also be compliant with SBx7-7 requirements.

PAs with discharges from irrigation are also subject to the Irrigated Lands Regulatory Program. While the original Program focused on surface water supplies, and implementation of best management practices to address surface runoff may have positive or negative implications for groundwater quality. Also, the ILRP long-term program requirements will include monitoring and BMP's for discharges to groundwater as well.

5.1.6 Replenishment of Groundwater Extracted by Water Producers

The hydrologic balance included in the previous GMP, suggests that lowering the groundwater levels increases sustainable yield, since subsurface outflow is reduced which counteracts the water extracted. More data and analysis is needed to confirm this finding and to determine the level of pumping that can be sustained without overdraft. As urban areas develop and there is a corresponding shift from surface water use to groundwater use, groundwater use increases and aquifer recharge decreases. Judging by the water resources balance, the GMA should be able to absorb the increased extraction due to increasing urban demand and maintain a balance. However, localized overdraft conditions could develop due to changes in surface water delivery, concentrated groundwater pumping, and water quality changes. The natural response of the aquifer to limited increases in pumping can provide for some replenishment.

Activities within the GMA:

- a. The Patterson General Plan update FEIR includes proposed policies to identify and locate opportunities for proposed groundwater recharge facilities in a joint effort with other local agencies, and to import or otherwise supply surface water to recharge local groundwater supplies.
- b. The Tracy ASR program will be injecting surface water into the groundwater aquifer to replenish storage depleted during drought periods, as discussed above in section 5.1.4.

5.2 Components Relating to Groundwater Quality Management

Groundwater quality management is critical to protect against the degradation that could adversely impact beneficial uses of available groundwater resources. Municipal, agricultural, and industrial activities can all increase the risk of polluting groundwater resources. Pollutants from these activities can find their way into the local aquifers degrading the water quality such that it becomes unusable for some beneficial uses without substantial treatment and cost. Some sources of pollution are natural. Through disruption in the existing barriers these low quality resources can intrude into higher quality groundwater resources, degrading the groundwater quality. Other sources are derived from anthropogenic applications and byproducts of human activities and waste. Degradation of groundwater resources can lead to expensive water treatment or loss of beneficial uses. The beneficial uses of groundwater resources may be sustained through proper monitoring and management of the resources and potential sources of degradation.

5.2.1 Regulation of the Migration of Contaminated Groundwater

Contaminants addressed in this section are those that result from improper application, storage or disposal of petroleum products, solvents, pesticides, fertilizers and other chemicals used by industry, and are distinguished from salinity degradation.

Activities within the GMA:

- a. The RWQCB has primary responsibility in enforcing water quality regulations, in the respective counties.
- b. By acting as the regional monitoring coordinator the SLDMWA will help develop a better understanding of the regional hydrogeology of the GMA, the vertical and lateral groundwater flow directions, and groundwater quality based on the various groundwater monitoring activities supporting this program. By distributing information and through coordination sessions, the SLDMWA will be able to make the PAs aware of changes in groundwater quality, which may indicate that new sources of contamination or changes in existing plumes of contamination are occurring.
- c. The San Joaquin County Environmental Health Department (SJCEHD) carries out different management programs. The purpose of the “Underground Injection Control” program is to protect public health and the environment from exposure to contaminants that may exist in shallow underground injection wells, such as dry wells, seepage pits, sumps, etc. These injection wells can transport contaminants to soil and groundwater. The primary focus is the protection of groundwater from contamination. Activities include identifying, mapping, inspecting and remediating potential or existing contaminant sources. The SJCEHD also permits and inspects well installation and destruction to minimize the potential for the wells to adversely impact groundwater.

The Underground Storage Tanks (UST) program was developed by SJCEHD to protect public health and the environment from exposure to hazardous materials stored in USTs. The primary focus is the protection of groundwater from contamination. Activities include inspection, permitting, monitoring, repair, installation and removal of USTs. UST sites with identified contamination are referred to the SJCEHD Site Mitigation Unit for cleanup oversight.

SJCEHD is also responsible for a Site Mitigation Database, which contains information about all the known hazardous material contamination sites within San Joaquin County. The database was established in 1993, although it includes information as far back as 1985. It is available to the public.

The Stanislaus County Department of Environmental Resources, Hazardous Material Division has an UST program. The goal of the program is to protect public health, the environment and groundwater. UST inspectors make certain that businesses and facilities with ongoing UST operations are properly permitted and meet the monitoring requirements applicable to their type of equipment. The UST Program and the Site Assessment and Mitigation Program oversee UST removal and soil clean-up activities. The primary function of the Site Assessment and Mitigation Program in UST removal activities is to provide regulatory oversight for the site assessment and mitigation of properties where unauthorized releases from UST systems have occurred.

The SWRCB developed a UST program which purpose is to protect public health and safety and the environment from releases of petroleum and other hazardous substances from tanks. By 2005, there were approximately 2,650 open UST cases in the Central Valley Region. There are four program elements: leak prevention program (requirements for tank installation, construction, testing, leak detection, spill containment and overfill protection), cleanup of leaking tanks, enforcement, and tank tester licensing. In addition, there is a database and geographic information system (GIS), Geo Tracker, which provides online access to environmental data (<http://www.geotracker.waterboards.ca.gov/>). It tracks regulatory data about underground fuel tanks and public drinking water wells, as well as other types of sites, such as above ground storage tanks and site cleanup cases (SWRCB, 2006).

Under the Pesticide Contamination Prevention act of 1985, the California Department of Pesticide Regulation (DPR) maintains a Ground Water Protection Program (DPR, 2011). Through the Ground Water Protection Program DPR evaluates risk and monitors for pesticide contamination in groundwater, identifies sensitive areas, and develops mitigation measures to prevent further contamination. DPR adopts regulations to protect groundwater as part of the Ground Water Protection Program.

The agricultural PA's are also subject to the RWQCB's Irrigated Lands Regulatory Program which is expected to require a groundwater monitoring program for specified constituents under general orders for waste discharge requirements. To the extent the PA's participate in the ILRP through a watershed coalition, the watershed coalition will be the primary venue for regional coordination, and PA's will need to coordinate their participation in both programs.

5.2.2 Development of Saline Water Intrusion Control Programs

Groundwater quality within an aquifer can be permanently degraded if saline groundwater migrates into the aquifer. Such degradation has the potential to render the groundwater unsuitable for some uses, particularly potable water use, if not treated. Desalination treatment systems are very expensive. In the GMA, saline water intrusion does not occur from an ocean or saltwater body.

5.2.3 Identification and Management of Wellhead Protection Areas and Recharge Areas

The Federal Wellhead Protection Program established by Section 1428 of the Safe Drinking Water Act (SDWA) Amendments of 1986 was designed to protect groundwater resources of public drinking water from contamination and to minimize the need for costly treatment to meet drinking water standards. A Wellhead Protection Area, as defined by the 1986 Amendments, is *"the surface and subsurface area surrounding a water well or well field supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water or well field."* In 1996, Congress reauthorized SDWA and amended it to require each state to develop and implement a Source Water Assessment Program.

In response to the 1996 re-authorization of the SDWA, Section 11672.60 amended to the California Health and Safety Code. Section 11672.60 requires the Department of Public Health Services (DHS, the precursor to DPH) to develop and implement a program to protect sources of drinking water, specifying that the program must include both a source water assessment

program and a wellhead protection program. In conformance with the legal mandate, the California's Drinking Water Source Assessment and Protection (DWSAP) Program was developed (DPH, 1999). The DWSAP Program addresses both groundwater and surface water sources.

In November 1999, the United States Environmental Protection Agency (USEPA) gave final approval of the DWSAP Program as California's Source Water Assessment and Protection program. The Department of Public Health (DPH) Division of Drinking Water and Environmental Management is the lead agency for development of the DWSAP Program and its implementation. California did not develop a separate Wellhead Protection program, thus the groundwater portion of the DWSAP serves as the State's Wellhead Protection program. In January 1999, USEPA approved the DWSAP as California's wellhead protection program.

According to the California Water Plan Update 2009 (DWR, 2009), recharge area protection includes keeping groundwater recharge areas from being paved over or otherwise developed and guarding the recharge areas so they do not become contaminated. Protection of recharge areas, whether natural or man-made, is necessary if the quantity and quality of groundwater in the aquifer are to be maintained. Existing and potential recharge areas must be protected so that they remain functional and they are not contaminated with chemical or microbial constituents. Zoning can play a major role in recharge area protection by regulating land-use practices so that existing recharge sites are retained as recharge areas.

In the GMA, an important source of groundwater recharge is derived from percolation of surface water as well as a small component of rainfall. In some cases pollutants associated with the percolating water can be transported from the surface into the underlying aquifer. The discharge of wastewater to land or surface water conveyance systems could, if improperly managed, pose a risk of polluting groundwater resources. The RWQCB has jurisdiction to regulate such discharges.

Activities within the GMA: Through programs administered by a variety of State agencies, the State of California regulates waste disposal. The PAs will rely on continued regulation by the State; however, currently, both Tracy and Patterson routinely monitor water quality from local groundwater production wells that supply potable water. Furthermore, to the extent parties subject to such permits request information from the PA's, require permission from a PA or are otherwise called to the PA's attention, PA's may advise the dischargers of the importance of protecting the groundwater resource and/or request notice and participate in the public comment opportunities of the agency with permit jurisdiction.

5.2.4 Administration of Well Abandonment and Well Destruction Program

State regulations require that all unused wells be properly abandoned or destroyed so that they do not act as conduits for mixing of groundwater of differing quality. Non-pumped wells are a much greater threat than pumped wells, since pumping normally quickly removes contaminants that may have migrated during idle periods. In gravel packed wells, the gravel pack as well as the casing itself can act as a conduit for mixing and potential contamination.

Permits are required from the local responsible jurisdiction, county or city, for abandonment of wells within their jurisdiction.

Activities within the GMA: The cities within the GMA defer this responsibility within their jurisdiction to the county health departments for well abandonment and destruction permitting. For public water supply wells, additional requirements may be prescribed by the DPH. Permit fees are normally required. The agricultural PAs rely on continued administration of the well abandonment and destruction program by the permitting agencies. The PAs' role in well abandonment and destruction is to provide available groundwater data, assist in identifying locations of operating and abandoned wells, and advise well owners why proper well destruction is important for protection of water quality.

5.2.5 Well Construction

Improperly constructed wells can establish pathways for pollutants to enter from surface drainage and can cause mixing of water between aquifers of differing quality. Sections 13700 through 13806 of the California Water Code require proper construction of wells. The standards of well construction are specified in DWR Bulletins 74-81 and 74-90 (DWR, 1981 and DWR, 1991).

The local jurisdictions, counties and cities, within the GMA have the fiduciary responsibility to enforce well construction standards within their jurisdictions. Well construction permits are required to drill a new well or to modify an existing well. Well Driller's Reports must be filed with the DWR and the respective counties.

Typically, it is the responsibility of the respective environmental health divisions of San Joaquin, Stanislaus and Merced Counties to permit and enforce standards for construction and abandonment of wells within their respective jurisdictions. The counties maintain records on these permitted wells as well as DWR. These data are publicly available and should be collected to incorporate into regional studies and monitoring programs, and may be supplemented with data on water levels and groundwater quality collected by other agencies to identify locations susceptible to intermixing of aquifer zones of varying water quality.

A better understanding of the subsurface geology and water quality is needed to define the confining beds between aquifer zones of differing water quality. Site-specific hydrogeologic investigations should be conducted to support well designs and should be submitted with the proposed well designs to obtain the well drilling permit.

Activities within the GMA: The cities within the GMA defer this responsibility within their jurisdiction to the county health departments for well construction permitting. Merced and Stanislaus Counties have adopted the DWR California Well Standards. San Joaquin County has developed its own standards that are slightly more rigorous than the DWR standards. The authority over well construction remains with the respective counties. The PAs may obtain information from the counties, such as copies of well permits, logs, and studies to assist in their groundwater management activities

5.2.6 Review of Land Use Plans to Assess Risk of Groundwater Contamination

Land use planning is used by counties and cities for regulation of land uses within their boundary or sphere of influence to create a quality of life and to achieve compatibility between man's

activities and the environment. It is a very effective method to mitigate impacts of changes in land use on groundwater quantity and quality.

Policies set forth in county general plans, city general plans, and community specific plans that affect groundwater may include:

- Regulating growth in groundwater recharge areas to protect water quality;
- Regulating development to improve water quality from storm water runoff and improve groundwater recharge opportunities;
- Monitoring water quality and groundwater levels;
- Providing planning for proper disposal of solid waste, sanitary waste, storm runoff, and hazardous wastes generated by the community;
- Restrictions to projected growth based on water consumption relative to available water supplies; and
- Mitigating the impacts of reduction in surface water supply resulting from conversion of land from agricultural use to urban use.

To achieve the common goals between the various land use plans and this GMP, close coordination between agencies is needed. During periodic land use plan preparation and updates, cities or counties should consult with the appropriate PAs to avail themselves of the latest information on hydrogeologic conditions that may be affected by proposed activities, so that appropriate mitigation measures can be included in the plans to avoid significant adverse impacts to local water resources. Proposed land use plans and supporting environmental documentation should be reviewed and commented upon by the PAs.

Activities within the GMA: Currently, The City of Patterson has proposed Low Impact Development policies as part of their General Plan update that should be followed during the planning process of development.

5.2.7 Construction and Operation of Groundwater Management Facilities

Groundwater management plans can include projects that protect the quality of groundwater and assure that the quantity of groundwater in storage is managed to meet long-term demand. The facilities that can aid in efficient management of groundwater resources include groundwater contamination clean-up projects, groundwater recharge projects, water recycling projects, and groundwater extraction projects. As knowledge is gained through implementation of the GMP components, specific projects may be identified and evaluated. The individual PAs are responsible for the development and implementation of those projects.

Activities within the GMA:

- a. Tracy developed a regional groundwater management plan to refine and address their specific needs and define projects to sustain the groundwater resources beyond those identified in this Basin-wide GMP.

- b. SLDMWA is in the process of developing a basin-wide groundwater monitoring plan that will include a groundwater monitoring network that will be developed following approval by DWR. This monitoring will assist the PAs in identifying projects to manage the groundwater resources.
- c. The City of Patterson has included programs in their water supply planning and policy documents to increase local groundwater recharge and protect groundwater quality.

5.3 Components Relating to Inelastic Land Surface Subsidence

Reducing the amount of groundwater in storage by pumping can cause the dewatering of fine-grained geological formations, potentially resulting in land subsidence and a reduction in the storage capacity of the aquifer.

The management of the land subsidence would include monitoring and prevention programs. Management of land surface subsidence should contain the following elements:

- Establish a subsidence monitoring program. Benchmarks should be established at well locations, so it would be possible to relate the subsidence to groundwater levels and extractions.
- Identify areas where monitoring suggests land subsidence.
- Identify groundwater management strategies that may be employed to minimize the subsidence.

Activities within the GMA: Tracy established a subsidence-monitoring program in 2003. Benchmarks were established near each of the City's monitoring wells. A benchmark level survey is performed in the spring periodically by using a Global Positioning System (GPS) initially calibrated with precise differential level surveys. The results of the Monitoring Program are presented in semiannual reports.

5.4 Components Relating to Surface Water Quality and Flow

SB 1938 requires the inclusion of components relating to the management of changes in surface flow and water quality that directly affect groundwater levels or quality or are caused by groundwater pumping. Specific actions may include:

- Use of surface water supplies when available in a recharge program or conjunctive use program that is sensitive to downstream users and the environment;
- Avoidance or mitigation of projects that detrimentally affect surface water quality and flow;
- Increase understanding of the interaction between surface water quality and groundwater quality through the GMA monitoring programs.

Activities within the GMA: The current and planned actions within the GMA related to recharge and conjunctive use are detailed in previous sections. Monitoring programs are being expanded through the SLDMWA basin-wide monitoring plan and network and also through the collection of information required under the ILRP.

Section 6

Groundwater Monitoring Programs and Plans

6.1 Groundwater Monitoring Programs

The purposes of a groundwater monitoring program are to identify areas of overdraft, provide information that will allow computation of changes in groundwater storage to evaluate net recharge or depletion, and identify the areas and extent of water quality degradation for potential mitigation. Groundwater level monitoring is essential to understand the impact on aquifer storage due to changes in water inflow and outflow components and in pumping activities. Mapping of groundwater levels depicts the direction of groundwater movement and the hydraulic gradient necessary for quantifying groundwater inflow and outflow to the GMA. Monitoring and mapping should be done independently in the unconfined and confined zones.

On behalf of the PAs, SLDMWA plans to take on the role as the groundwater Monitoring Entity within the GMA, in accordance with the requirements set forth in SBx7-6. As of January 2011, SLDMWA notified DWR that they are planning to assume the responsibility for the groundwater Monitoring Function within the GMA. Additionally, SLDMWA is preparing a groundwater monitoring plan, assuming this role as an Umbrella Monitoring Entity in a collaborative effort with USBR and the PAs. This plan will describe the proposed groundwater monitoring program in detail. It is anticipated that this plan will be submitted to DWR by the summer of 2011 for review and approval, and Monitoring Functions within the GMA undertaken by the PAs with SLDMWA as the lead entity on or before January 2012. The proposed monitoring program would rely on the collaboration with the PAs to perform any necessary measurements and collect groundwater elevation data for regular submittals to DWR, at a minimum annually. As an Umbrella Monitoring Entity, SLDMWA will collect and compile the water level data gathered by the PAs for submittal to DWR. The proposed groundwater monitoring plan will describe:

- A program for collaborating with and coordinating the efforts amongst the PAs to monitor groundwater levels within the GMA;
- Standard procedures and methods for the measurement and collection, quality assurance, and documentation of field data;
- A DWR approved monitoring network comprised of monitoring wells selected to be representative of the groundwater conditions throughout the GMA, including a map of the proposed monitoring locations;
- A monitoring schedule that is coordinated amongst the PAs and approved by DWR that facilitates evaluation of seasonal and long-term trends in groundwater levels;
- Standard protocols for the gathering and coordination of data from the PAs and other agencies, as applicable, like DWR, USGS, DPH, San Joaquin County, Stanislaus County, and Merced County;
- Standard procedures for reporting results and findings to the PAs for evaluation; and,
- Standard protocols for data transmittal from the SLDMWA to DWR.

As part of this groundwater monitoring plan, groundwater levels will be reviewed by the PAs. An annual report will be prepared that describes the groundwater monitoring results, and evaluates developing trends and the condition of the aquifer. Based on the information presented in the annual report, the PAs, through a steering committee, will determine if additional activities are warranted. Some details regarding the sources of groundwater data from within the GMA are identified below.

DWR

In the past, DWR measured groundwater levels in wells and maintained a database of the groundwater measurements statewide. Currently, DWR maintains publicly available statewide groundwater level data at the Department's Groundwater Level Database website (<http://www.water.ca.gov/waterdatalibrary/>). This site provides a graphical interface that allows selection of individual wells from a local area map. Data can also be retrieved by specifying the groundwater basin or township of interest. A selected well will return a groundwater level hydrograph and data table including the depth to water below reference point, elevation of water surface and depth to water below land surface. This site currently maintains groundwater level information for nearly 18,000 wells within the San Joaquin District boundary and about 60,000 wells statewide.

With the passage of SBx7-6, DWR will be relying on local entities to take on the responsibility of measuring groundwater levels within basins in conformance with a DWR approved monitoring plan and schedule, and submitting the data to DWR. The data will be uploaded to a DWR database in conformance with DWR protocols. Therefore, the number of groundwater monitoring locations, and continuity with previous locations may change as the monitoring responsibility transitions from DWR to local monitoring entities, and new monitoring networks and schedules are established. Information regarding the SBx7-6 requirements may be obtained through the DWR at the California Statewide Groundwater Elevation Monitoring (CASGEM) website (<http://www.water.ca.gov/groundwater/casgem/>).

USGS

USGS maintains the Ground-Water Data for the Nation database, which contains groundwater site inventory, groundwater level data, and water quality data (<http://waterdata.usgs.gov/nwis/gw>). The groundwater site inventory consists of more than 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in the United States. Available site descriptive information includes well location information such as latitude and longitude, well depth, and aquifer. The USGS annually monitors groundwater levels in thousands of wells in the United States. Groundwater level data are collected and stored either as discrete groundwater level measurements or as continuous record. The data available for this GMA has not been updated.

USGS, in concert with other State and Federal agencies, developed and maintains a hydrologic model of the Central Valley of California. The CVHM is a MODFLOW model developed from a comprehensive geospatial database of numerous features of the heterogeneous Central Valley aquifer system. According to USGS, CVHM will be operated by USGS and made available for use by water managers and other agencies. It was designed to help resource agencies assess, understand and address the many issues affecting the use of surface water and groundwater supplies in the Central Valley. It is intended to aid water managers by simulating a number of

water-management scenarios and assess possible changes in both groundwater and surface water supplies on a regional scale. CVHM generally has a resolution of about 1 mile spacing between nodes. However, at the request of SLDMWA through USBR, CVHM resolution is being increased by USGS to approximately ¼ mile spacing between nodes within the areas serviced by SLDMWA, including the GMA. This improvement to the CVHM, within the SLDMWA Service Area, was requested to aid in modeling of potential subsidence from water withdrawal and to assist PAs with alternatives impact analyses for local project decision-making through groundwater modeling. The model can take into account a number of hydrologic factors including the conversion of farmland to urban use, groundwater recharge and extractions, and the effects of climate change. Limitations on the application of CVHM due to the scale used in calibration may be encountered in some smaller applications by water managers. Upon request, USGS can incorporate additional data into the CVHM to refine the input parameters and calibration, thus providing improved accuracy and precision, within a specified region. Information regarding the CHVM may be obtained through USGS (Contact: Claudia Faunt, Phone: 619-225-6142; ccfaunt@usgs.gov).

SWRCB – USGS – Lawrence Livermore National Laboratory (LLNL)

The SWRCB is collaborating with the USGS and the LLNL to implement the GAMA Program. The GAMA Program is a statewide comprehensive groundwater quality monitoring program, developed in response to the Groundwater Quality Monitoring Act of 2001 (Water Code sec.10780-10782.3). The goals are to improve statewide groundwater monitoring, and facilitate the availability of information about groundwater quality to the public. The data collected will provide an indication of potential water quality problems. It will also be used to identify the natural and human factors affecting groundwater quality. Prior to 2003, the GAMA Program conducted the California Aquifer Susceptibility (CAS) Assessment. The CAS Assessment addressed the relative susceptibility to contamination of public wells. This effort was the foundation for the GAMA Program. The GAMA Program also addresses the quality of private/domestic drinking water wells through the Voluntary Domestic Well Assessment Project.

As part of the GAMA Program, the groundwater basins in California were ranked in groups of sampling priority on the basis of the number of public wells, groundwater usage, and potential sources of groundwater contamination in each basin. Three types of water quality assessments were conducted for each unit:

1. The assessment of current groundwater quality.
2. The detection of changes in water quality.
3. The assessment of natural and human factors that affect groundwater quality.

To efficiently facilitate a statewide, comprehensive program most efficiently, uniform and consistent study-design and data-collection protocols were applied to the entire state.

There are four currently active components of the GAMA Project:

1. GeoTracker GAMA: GeoTracker GAMA is a program to develop and implement a user-friendly internet accessible to georeferenced groundwater database. Data are searchable by text or through an interactive map for groundwater constituents, location and other parameters. The database includes over 150,000 sampling locations. GeoTracker

GAMA provides tools to integrate, standardize, and analyze data from several datasets, including data from:

- California State Water Resources Control Board (SWRCB)
- California Regional Water Quality Control Boards (RWQCB)
- California Department of Public Health (DPH)
- California Department of Pesticide Regulation (DPR)
- California Department of Water Resources (DWR)
- United States Geological Survey (USGS)
- Lawrence Livermore National Laboratory (LLNL)

More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/geotracker_gama.shtml#).

2. Priority Basin Project: The GAMA Priority Basin Project assesses groundwater quality in key groundwater basins in the State. Groundwater is monitored for hundreds of chemicals at low detection limits, including emerging contaminants such as pharmaceuticals and personal care products. The GAMA Priority Basins consist of 116 of the 472 DWR defined groundwater basins in the State. The GAMA Priority Basin Project is grouped into 36 groundwater basin groups called “study units”. Each study unit is sampled for common contaminants regulated by the DPH, and also for unregulated chemicals. Some of the chemical constituents that are sampled by the GAMA Priority Basin Project include: volatile organic compounds (VOCs); pesticides; Stable isotopes of oxygen, hydrogen, and carbon; emerging contaminants; trace metals; radioactivity; general ions; nutrients; and bacteria. Monitoring and assessments for priority groundwater basins is on-going and will be completed every ten years, with trend monitoring every 3 years. Initial testing of and reporting on the groundwater quality is being conducted currently. More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/priority_basin_projects.shtml).
3. Domestic Well Project: The GAMA Domestic Well Project collects and tests samples from private domestic water supply wells, whose owners have volunteered for the program, for commonly detected chemicals. Domestic well water is for private use and consumption. Its quality is not regulated by the State. The results of the testing for each well are shared with the well owner, and used to evaluate the quality of groundwater used by private well owners. The Domestic Well Project has sampled five County Focus Areas in California as of 2009: Yuba, El Dorado, Tehama, Tulare, and San Diego. None of which lie within the GMA. In general, the Domestic Well Project tests for constituents that are a common concern in potable water: bacteria, general minerals, general chemical parameters, inorganic chemicals and nutrients, and organic chemicals. The results are compared to CDPH drinking water standards. More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/domestic_well.shtml).
4. Special Studies Project: The GAMA Special Studies Project consist of a number of studies undertaken by LLNL, to look at various relationships between land uses, management practices, and other activities and the effects these activities have on local groundwater resources. LLNL has conducted several groundwater special studies. Of which, Seven projects have been completed; five reports have been published with

numerous scientific papers and presentation. The studies completed consist of the following:

- The fate & transport of nitrate sources from dairies
- Nitrate management plan studies for the Llagas Basin (Gilroy), and Chico Basins
- The fate and transport of nitrate sources and occurrence, and its relation to land usage (fertilizer, wastewater, and/or agricultural)
- Nitrate sources and occurrence in Orange County
- Nitrate sources and occurrence in Livermore
- Wastewater indicator study
- A wastewater indicator study on how septic systems affect shallow groundwater
- A wastewater indicator study of areas irrigated by recycled water in Gilroy and Livermore.

The Special Studies still in progress address groundwater recharge, changes in chemistry of groundwater recharged by surface waters, and development of a field deployable apparatus for extraction and collection of dissolved gasses from groundwater samples. More information about this program is available through SWRCB (http://www.waterboards.ca.gov/gama/special_studies.shtml).

Findings from the initial studies conducted as part of the Priority Basin Project for the Northern San Joaquin Study Unit have been completed and published by USGS, and are available at the GAMA Program website (<http://ca.water.usgs.gov/gama/SU/nsjv.htm>). The northern portions of the GMA within San Joaquin County lie within the Tracy Subbasin, which in turn lies within the western portion of the Northern San Joaquin Study Area (Bennett, G.L., *et.al.*, 2006). The remainder of the GMA lies within the Delta Mendota Subbasin, which lies within the Western San Joaquin Valley Study Unit. The initial sampling and testing of groundwater from wells located in the Western San Joaquin Valley Study Unit is currently being completed and the findings are scheduled to be published in early 2011 (Contact: jshelton@usgs.gov). More information about this program is available through SWRCB or USGS (<http://www.waterboards.ca.gov/gama/> or <http://ca.water.usgs.gov/gama/>).

DPH - Division of Drinking Water and Environmental Management

Every public water system in the State has to have the analyzing laboratory enter the results of all chemical monitoring to the Drinking Water Program, a water quality monitoring database. A CD containing the database can be purchased from the Monitoring and Evaluation Unit (Contact: Steve Book, Phone: 916-449-5566; sbook@dhs.ca.gov). For security reasons, DPH does not provide the coordinates of each well included in the database. However, general location information is easy to deduce from names of the water systems.

SLDMWA

The PAs cooperatively developed a comprehensive groundwater level and quality monitoring plan for the GMA (Stoddard & Associates, 1999). Currently, only the groundwater levels are monitored twice a year at a portion of the wells identified in the plan. Other elements of the plan have not yet been implemented, though implementation of additional elements will occur in the

future as the groundwater monitoring plan is prepared and approved by DWR. (Contact: Joe Martin, Phone: 209-832-6241; joe.martin@sldmwa.org.)

San Joaquin County

The San Joaquin County Groundwater Data Center (GDC) is a countywide centralized groundwater information medium that provides access to groundwater data collected and shared by agencies throughout San Joaquin County. The county groundwater level monitoring program includes semi-annual measurements of over 550 wells, of which approximately 300 are measured by county staff. The data collected is stored electronically in a database for further analysis. Historic groundwater data are accessible through the internet at the GDC website (<http://www.sjmap.org/groundwater/>).

Stanislaus County

The County has groundwater quality information available from the Public Water System database. An appointment is necessary to gather that information. At this time, there is no groundwater level information available. (Contact: Tom Wolf, Phone: 209-525-6756)

City of Tracy

Tracy developed a Mitigation Monitoring Program in 2001. The monitoring network consists of eight active production wells, four nested monitoring wells, and 18 clustered monitoring wells. Because of the design of the monitoring wells, data from those wells are considered representative of individual aquifer conditions and are generally of higher quality than the data obtained from production wells. Groundwater levels are obtained monthly, and water quality is collected quarterly. This program also includes a subsidence survey. The annual benchmark survey is performed in the spring periodically. The results of the monitoring program are presented in semiannual reports (GEI Consultants, 2005). (Contact: Steve Bayley, Phone: 209-831-4420; steve.bayley@ci.tracy.ca.us.)

6.2 Monitoring Plans

SB 1938 requires the adoption of monitoring protocols designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin. The monitoring protocols shall be designed to generate information that promotes efficient and effective groundwater management.

For this GMP, monitoring protocols will be defined based on goals of particular programs. As part of the requirements of SB 1938, the PAs must adopt monitoring protocols to measure changes in water levels and quality, subsidence where subsidence has been identified as a potential problem, and flow and quality of surface water directly influenced by groundwater.

Under the requirements of SBx7-6, the SLDMWA has notified DWR as the monitoring entity for the GMA on behalf of the PAs. As the Umbrella Monitoring Entity in the GMA, SLDMWA is responsible for coordinating the activities of the PAs with regard to groundwater monitoring, including development of schedules, approved monitoring network, and standardized collection

techniques for groundwater level monitoring, groundwater quality sample collection, preparation, documentation, laboratory procedures and methods, and data validation and transfer procedures. All of these elements are described in the recent Groundwater Monitoring Plan prepared by SLDMWA. The Groundwater Monitoring Plan should be adopted by the PAs, and then approved by DWR by the summer of 2011, and implemented before the end of 2011. SLDMWA, through consultation with the PAs, will describe in the Groundwater Monitoring Plan the framework for analysis of data and dissemination of the results in conformance with DWR data transfer protocols. There are currently 6 proposed elements, or plans, considered for the Groundwater Monitoring Program.

Data Collection

This proposed element will describe a data collection plan to ensure that data is collected in a consistent manner that produces meaningful data for reporting. To this end, this element will include procedures associated with the data collection process, such as the protocol for sampling and/or measuring point location, frequency of sampling/measuring, what entity performs the sampling/measuring, quality assurance, quality control, documentation requirements, well owner notification procedures and parameters to be monitored. This element will also include a description of procedures for obtaining access permission from well and/or land owners, for documenting special access requirements, for marking and identifying monitoring points, and for obtaining and documenting site conditions and survey information regarding the monitoring points.

Groundwater Elevation Monitoring

This proposed element will describe a groundwater elevation monitoring plan to provide accurate and dependable groundwater well depth-to-water field measurements that are the basis for evaluating the long-term trends in the change in groundwater levels and quantity within the GMA. This element will include procedures and schedules for conducting groundwater level measurements to determine groundwater elevations. A schedule for conducting measurements will be included and will be based on sampling periods most likely to be representative of long-term groundwater conditions, anticipated to likely occur in spring and fall of each year based on current understanding of regional conditions. In addition, groundwater level information will also be regularly collected from continuously monitoring instrumentation affixed to a number of groundwater monitoring points throughout the GMA. Groundwater level data will be incorporated into the SLDMWA database in accordance with data collection protocol and uploaded to the DWR web-based database at least once a year in accordance with DWR protocol.

Groundwater Quality Monitoring

This proposed element will describe a groundwater quality monitoring plan to track various groundwater constituents of concern that may demonstrate long-term trends in water quality that may adversely impact the beneficial uses of groundwater within the GMA and to allow early detection of potential trends as they develop so that timely remedial actions may be undertaken. Water quality testing will be conducted routinely on wells within the GMA discharging to the Delta Mendota Canal. Additionally, water quality testing will be conducted on some USGS wells. Groundwater quality data will be incorporated into the SLDMWA database in accordance

with data collection protocol and uploaded to the DWR web-based database at least once a year in accordance with DWR protocol.

Groundwater Extraction Monitoring

This proposed element will describe a plan for documenting the amount and location of groundwater extracted from within the GMA to aid in evaluating of groundwater conditions. Groundwater pumping will be measured at a number of wells within the GMA affixed with meters, many of which are currently measured for discharge to DMC under Warren Act Contract. Groundwater extraction data will be incorporated into the SLDMWA database in accordance with data collection protocol and may be uploaded to the DWR web-based database at least once a year in accordance with any applicable DWR protocol.

Land Subsidence Monitoring

This proposed element describes a plan to measure land subsidence and to predict the potential for further subsidence. Continuously operating subsidence monitoring stations have previously been installed within the GMA, which will be utilized to measure subsidence. Tentatively, it has been proposed that data will be collected monthly. Subsidence monitoring data will be incorporated into the SLDMWA database in accordance with data collection protocol and may be uploaded to the DWR web-based database at least once a year in accordance with any applicable DWR protocol.

Reporting

This proposed element describes a plan for reporting the results of the monitoring program. As the Umbrella Monitoring Entity representing the PAs, SLDMWA will take undertake the responsibility of coordinating the collection and compilation of all applicable groundwater well data within the GMA, and regularly submit the data, at a minimum annually, to the DWR in conformance with the CASGEM protocol. Additionally, it is anticipated that as part of the program, an annual Groundwater Monitoring Report will be prepared that summarizes the water quality, water level, water extraction and subsidence data collected throughout the year. It is anticipated that this report will provide summary information including maps, figures, charts, and tables to characterize water quality, water level and subsidence trends occurring within the GMA. Finally, in accordance with agreements with USGS, SLDMWA will submit data reports on a regular basis to USGS for incorporation into the USGS Central Valley Groundwater Study, and the groundwater flow and land-subsidence model that is currently being developed within the SLDMWA boundaries.

Section 7

Implementation of the Groundwater Management Plan

The GMP implementation involves development of programs through cooperative efforts of the PAs. Implementation of some aspects of the plan may require considerable expenditures and formulas must be developed to allocate costs amongst the PAs. Implementation of regional groundwater management plans is ultimately less costly than implementation of plans by individual agencies, but the implementation strategy is complicated since the PAs have varied reliance on the groundwater resource. The priorities for implementation of the various elements of the GMP will vary from PA to PA. The potential benefits of regional planning within a common groundwater basin or subbasin far outweigh the difficulties of plan implementation. The cooperation of agencies increases the opportunities for water resource management.

In the GMA, the PAs can be generally separated into four categories:

1. Urban water users that currently rely exclusively or primarily on groundwater.
2. Agricultural water users who rely solely on groundwater for water supply.
3. Agricultural water users that rely on surface water and use groundwater for supplemental supply.
4. Agricultural water users with sufficient surface water supply, with groundwater used only for incidental purposes.

Depending on the category, a PA will be willing to invest an appropriate amount of time, effort, and financial resources into groundwater management and make the investment in those management elements that affect it the most. It cannot be expected that all agencies will invest equally in all the elements of the GMP. Hence, an implementation strategy must provide flexibility in the level of agency participation in each element of the plan. For instance, urban agencies and agricultural agencies that rely solely on groundwater supplies may be much more prone to invest in controlling saline water intrusion and localized overdraft; whereas, urban agencies may be more interested in wellhead protection or controlling migration of contaminated groundwater. Participating in conjunctive use operations is obviously desirable for those PAs with water supply deficits, but may also be attractive to those with surplus surface supplies that can be used for recharge purposes.

With consideration given to the reliance upon groundwater by the PAs and the varying importance of the groundwater management elements, the recommended implementation strategy is as follows:

- After public review and consideration of comments received, the final plan should be adopted by each agency.
- The SLDMWA will facilitate coordinating plan implementation among the PAs.
- Groundwater monitoring data collected annually will be provided to a consultant with expertise in hydrogeology and local groundwater conditions for review and preparation

of an annual report that will include a summary of the groundwater data, discussion of developing trends and recommendations for groundwater management strategies.

- Under the SLDMWA Activity Agreement, the Steering Committee made up of representatives of the PAs will meet at least twice a year to:
 - 1) Review findings of the groundwater monitoring program and developing trends,
 - 2) Based on the annual findings, consider and recommend that the PA's adopt new regional groundwater policies as necessary,
 - 3) Review particular projects being implemented or proposed by the PAs and their potential impacts, and
 - 4) Assist the PA's to coordinate policies and projects under the regional GMP.
- With consideration given to the identified problem areas, the committee shall establish a recommended priority list for management actions.
- Management activity groups will be formed, as needed, of those participating agencies interested in implementing certain elements of the groundwater management plan to identify specific management actions, develop budgets, and apportion costs.
- Once a year, each PA will provide a summary of the status of their ongoing programs and any proposed programs to be implemented within the following year for consideration by the PAs and for coordination purposes.
- An annual summary would be prepared to report the current state of the basin and describe the management activity that has taken place for each plan element. It would be used to keep PAs and the SLDMWA abreast of the group's activities.
- At least once a year the PAs will meet to discuss budgets and cost allocations for SLDMWA activities in facilitating and coordinating the regional monitoring program and any other SLDMWA expenditures needed to facilitate and coordinate implementing agreed upon groundwater management programs within the GMA.

This GMP is a living document and as such is expected to adapt as more information becomes available through the various programs instituted within the GMA, as conditions change, and as the needs of the PAs evolve. Thus, this implementation strategy is expected to be refined as necessary by the management committee.

Section 8

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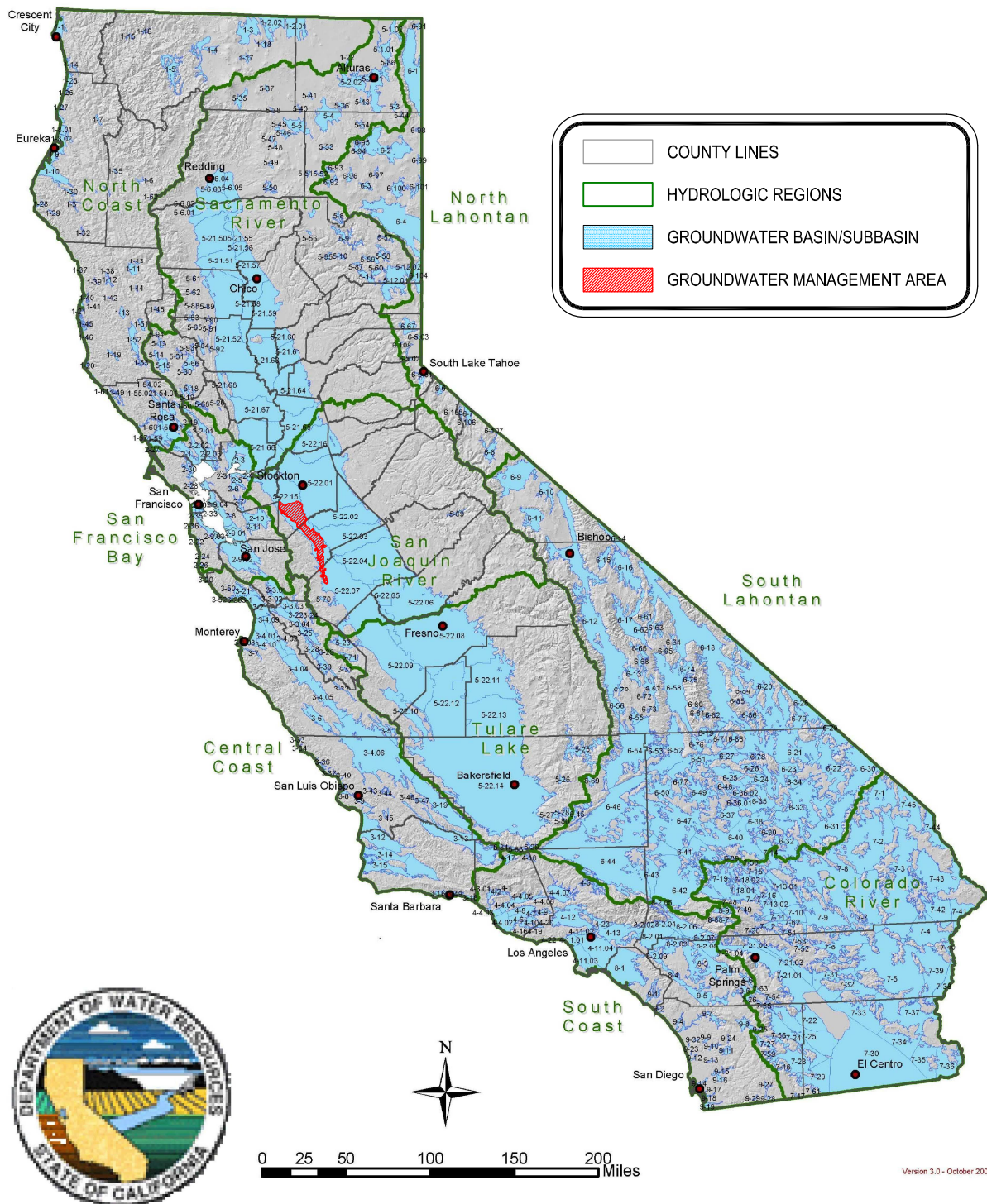
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FIGURES

Groundwater Basins in California



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FIGURE

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SUB-BASINS OF THE SAN JOAQUIN RIVER
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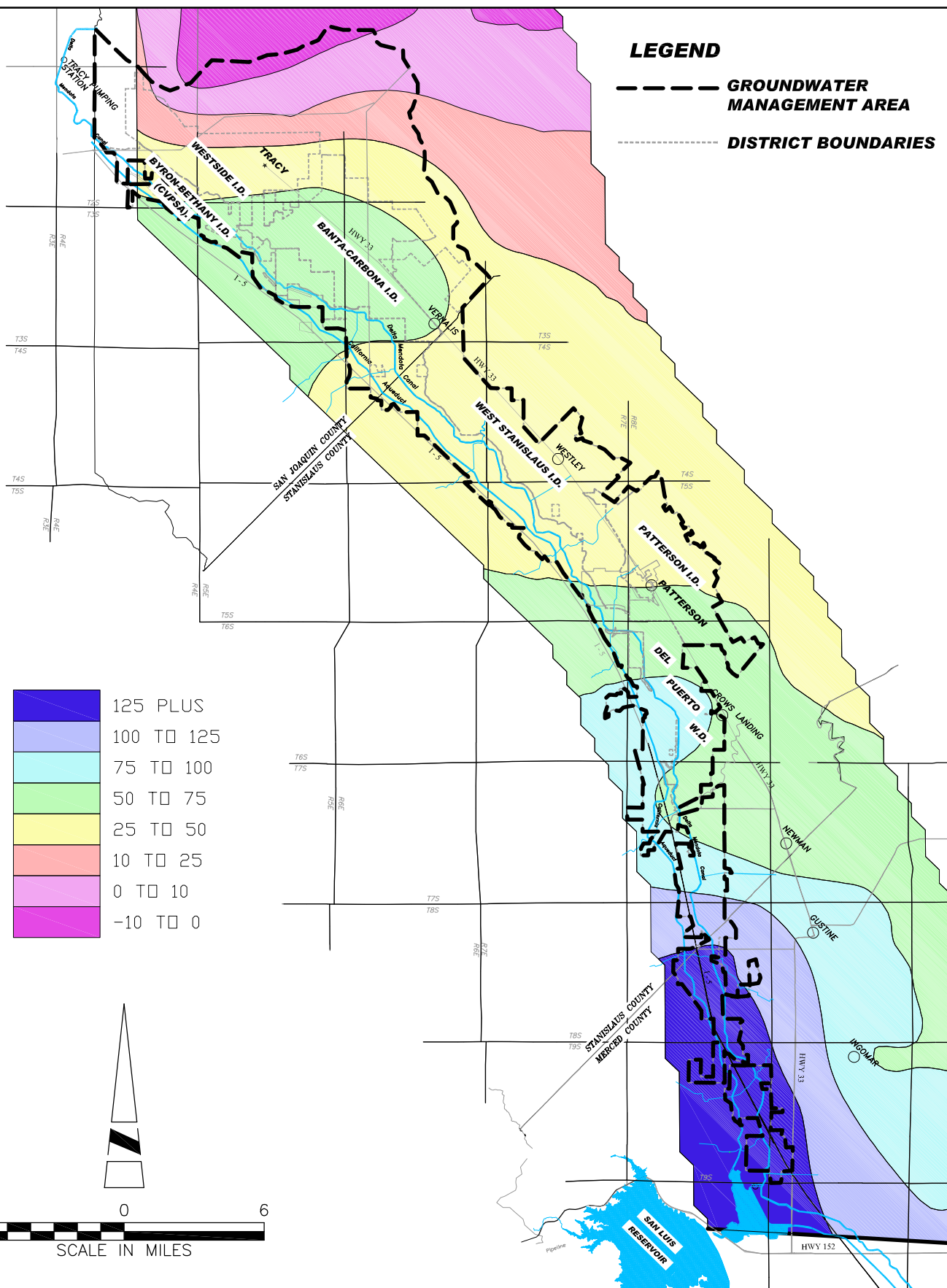
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WATER TABLE ELEVATION
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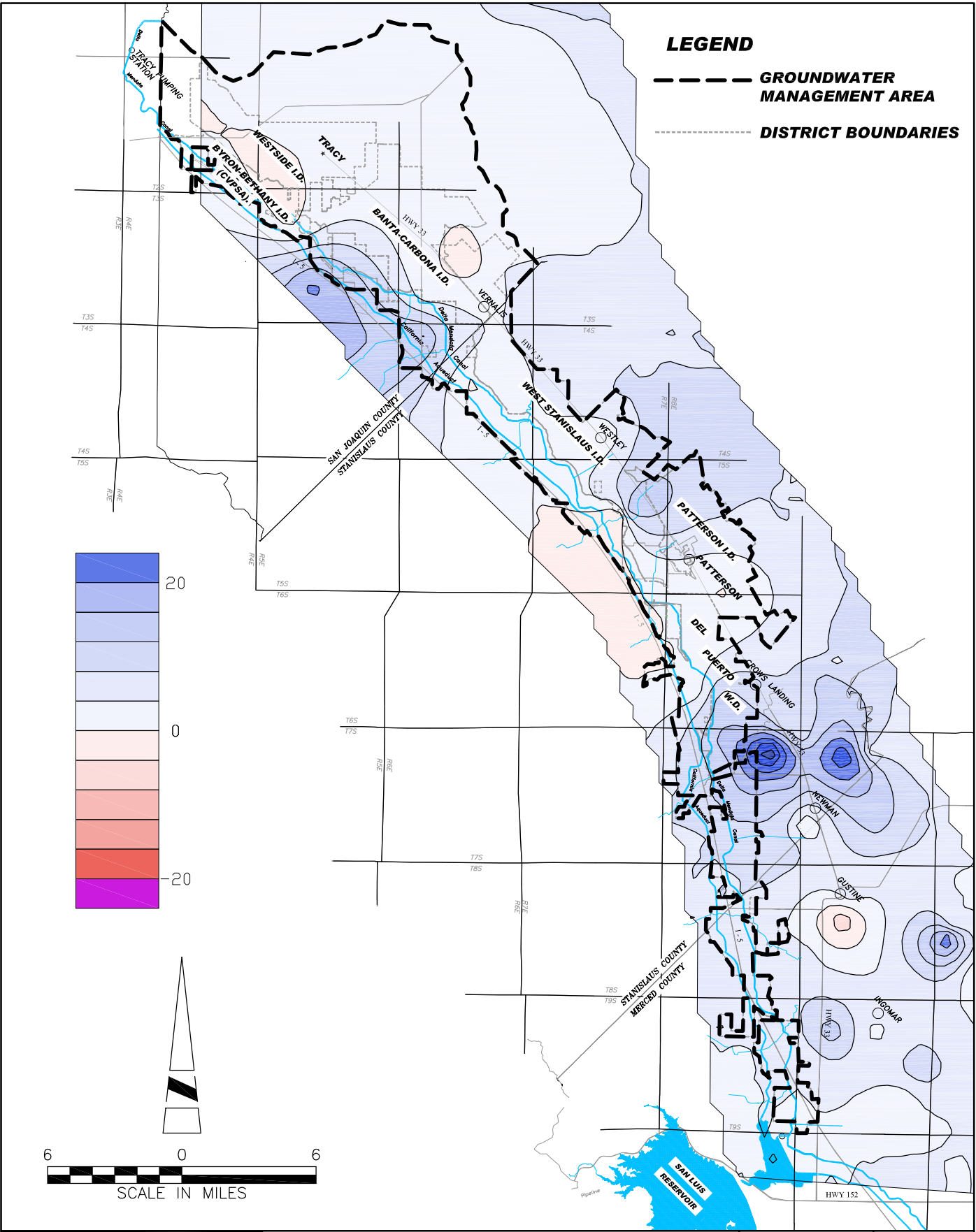
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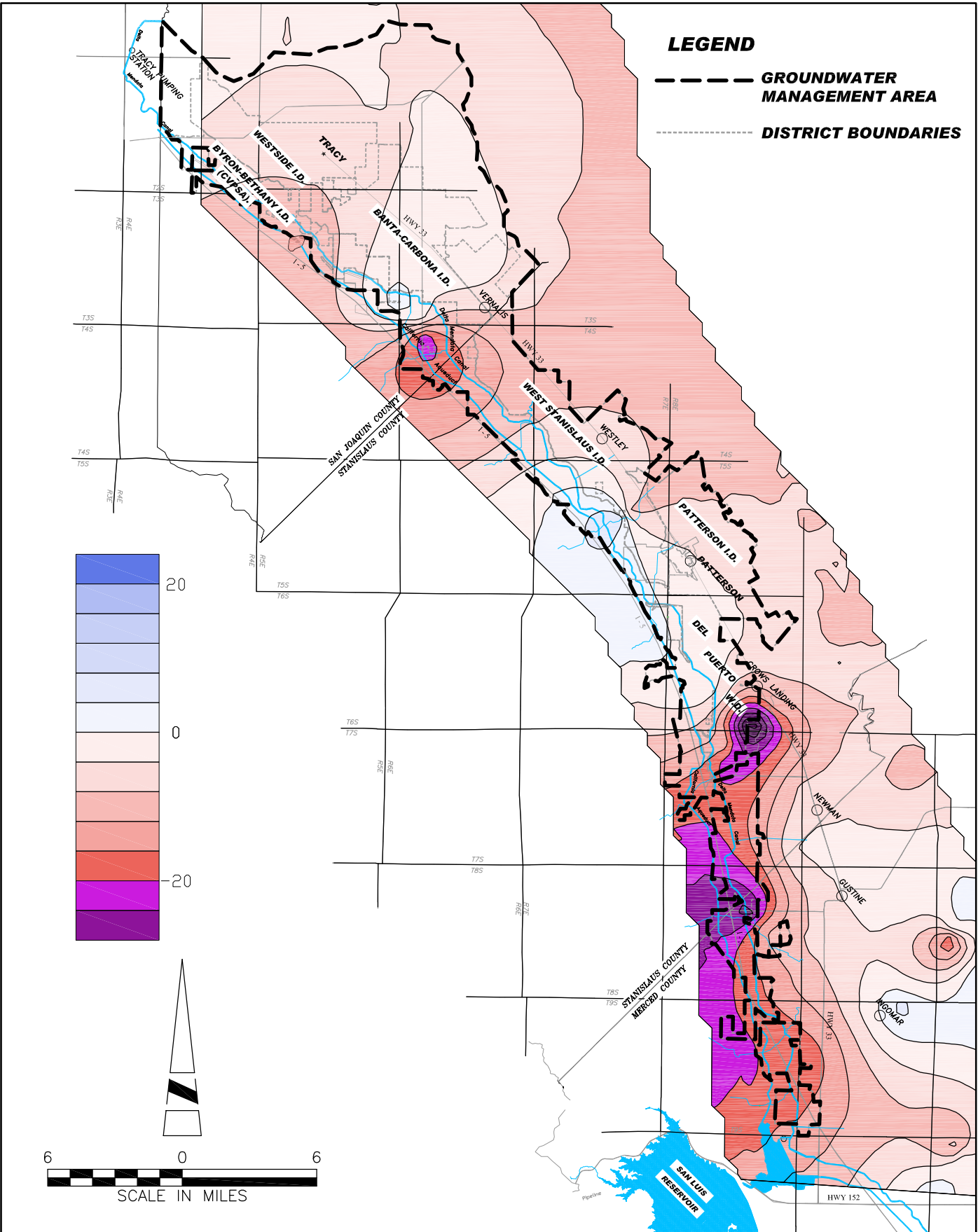
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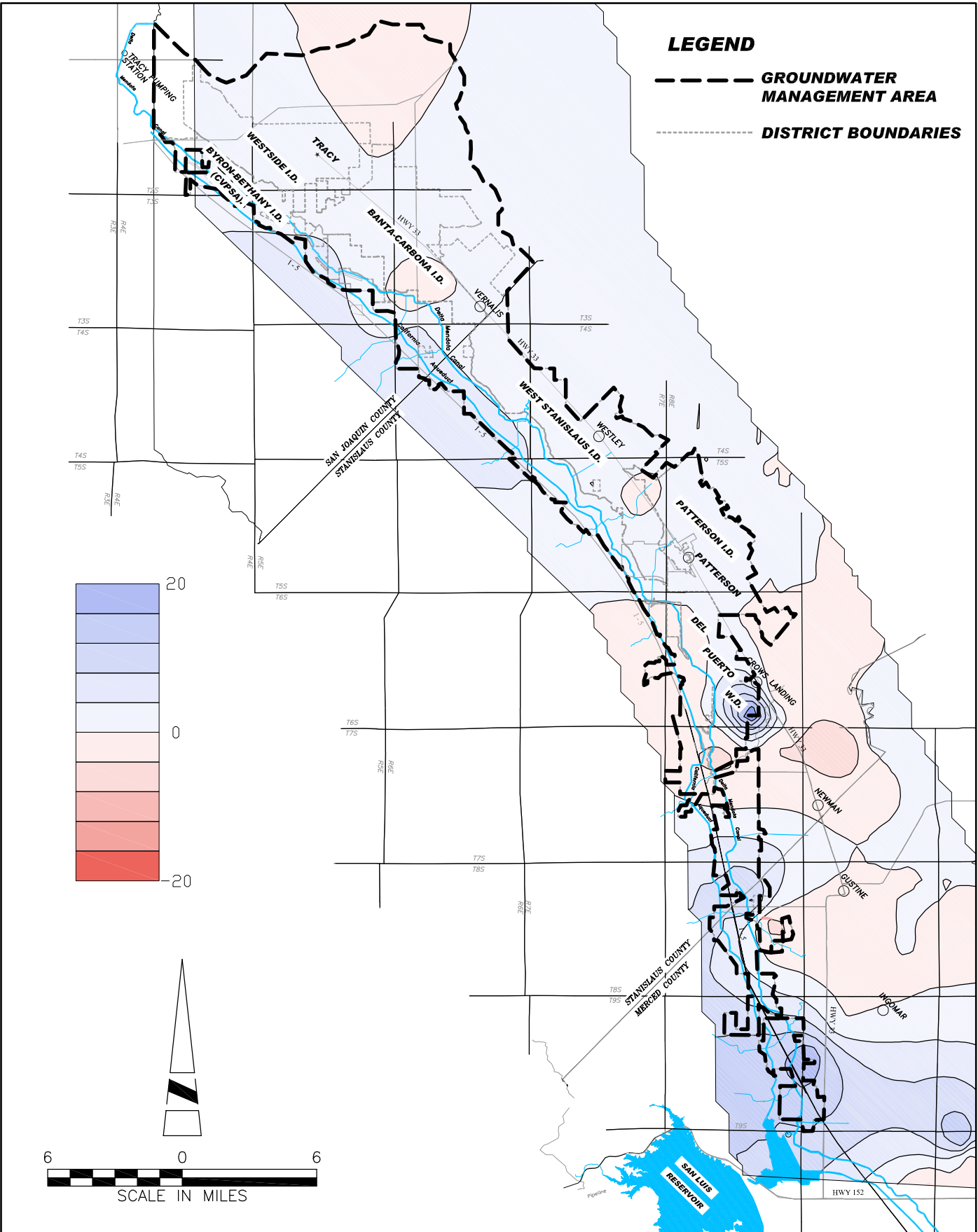
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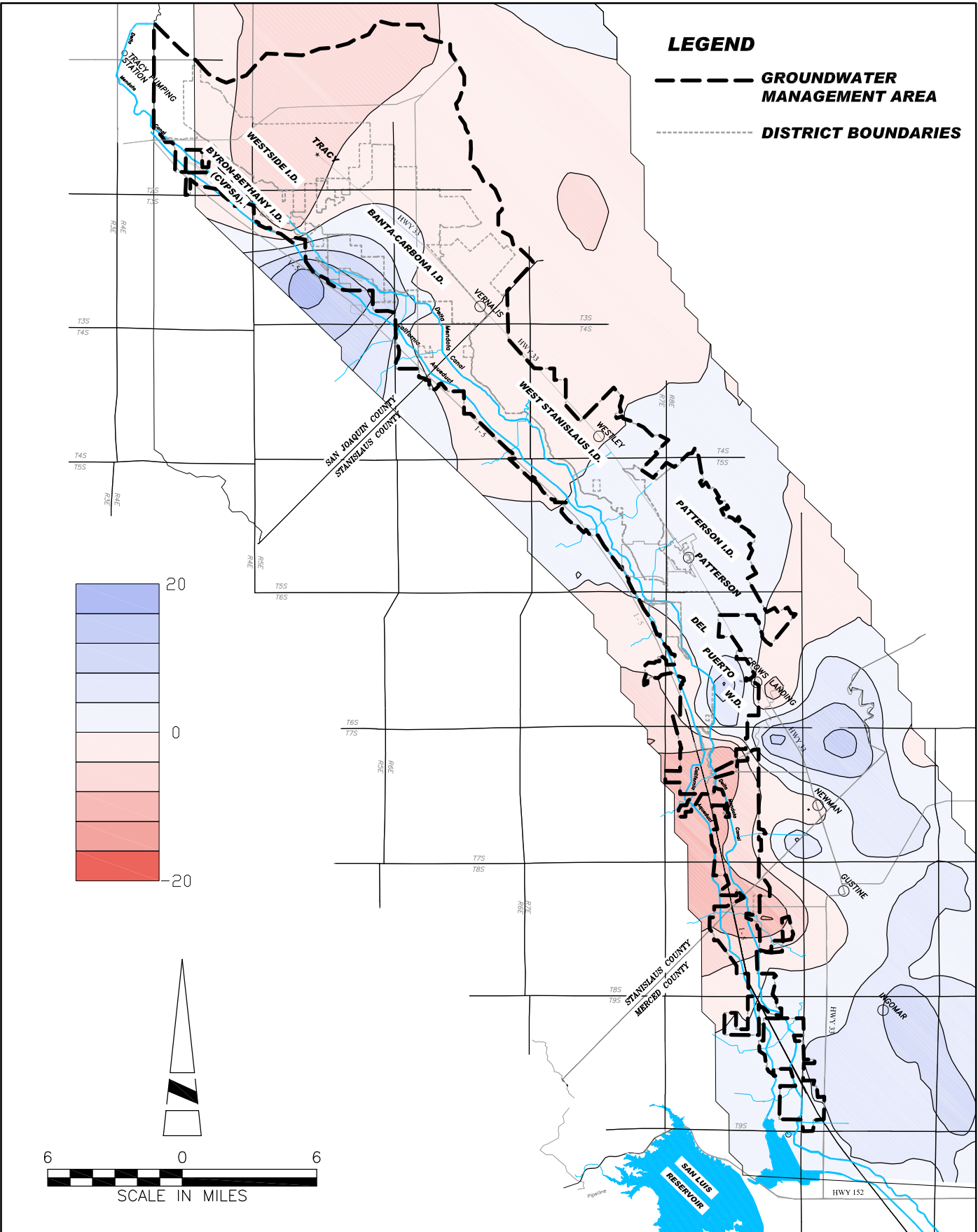
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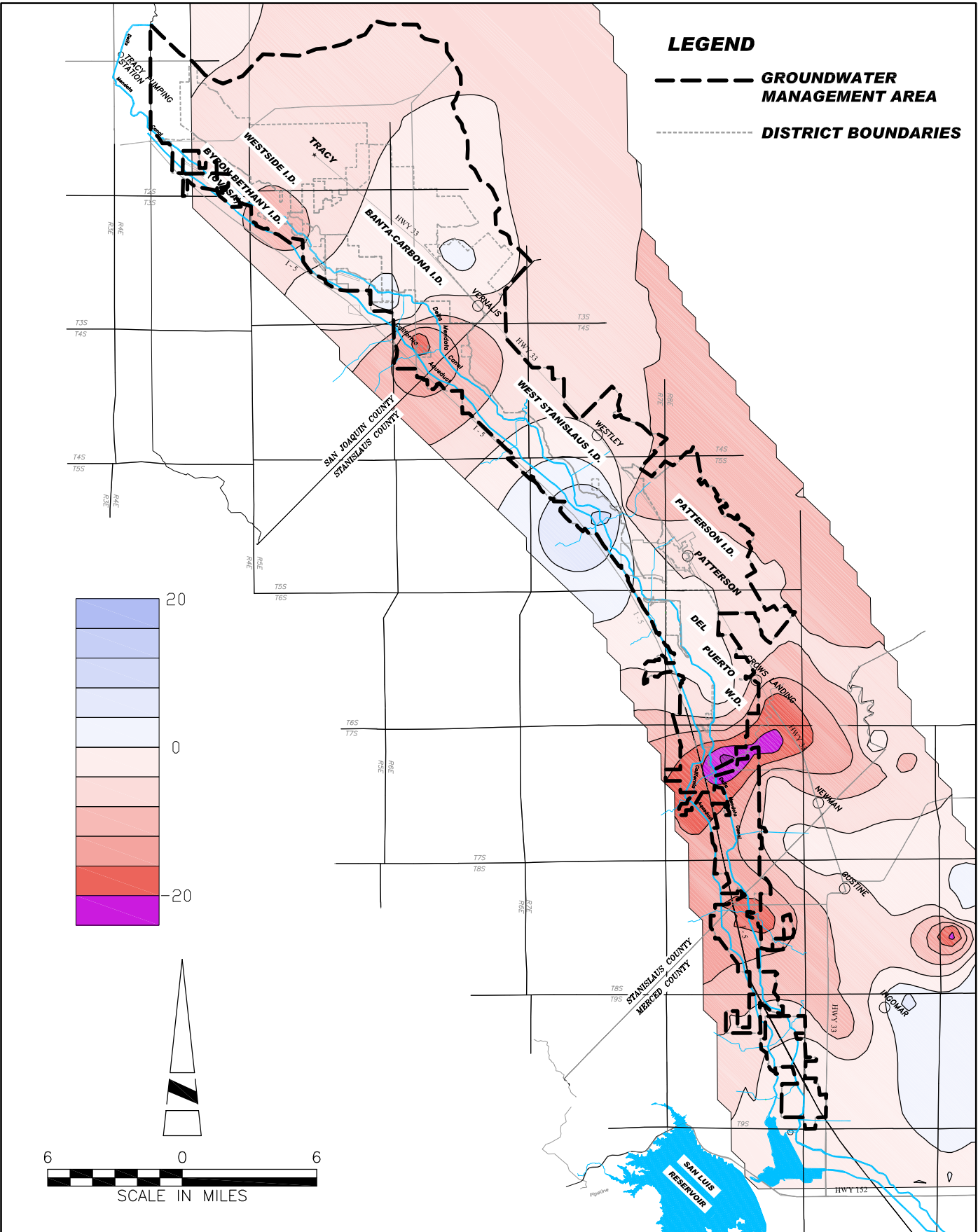
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FIGURE

10

APPENDIX A

USBR GAMA Water Quality Data for Tracy Subbasin Area

Table 4
Findings from GAMA Priority Basins Program for Tracy Subbasin Area of the Northern San Joaquin Study Area

		Threshold type	Threshold level									
GAMA well identification number	Units			TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05	
Sample Date	(mm/dd/yy)	n/a	n/a	1/5/2005	1/6/2005	2/8/2005	2/17/2005	1/4/2005	1/5/2005	1/5/2005	1/5/2005	
Well head altitude	(ft above LSD)	n/a	n/a	16	207	105	26	29	22	199	45	
Year of construction		n/a	n/a	1953	1989	1997	1985	1961	n/a	1988	1989	
Well depth	(ft below LSD)	n/a	n/a	502	900	340	400	1148	400	870	990	
Top perforation	(ft below LSD)	n/a	n/a	384	420	320	310	337	n/a	420	490	
Bottom perforation	(ft below LSD)	n/a	n/a	480	890	340	400	561	n/a	850	980	
Total open length	(ft)	n/a	n/a	96	470	20	90	224	n/a	430	490	
Number of openings		n/a	n/a	1	1	1	2	5	n/a	1	1	
Turbidity(61028)	(NTU, field)	n/a	n/a	nc	0.2	nc	nc	0.1	nc	0.2	nc	
pH (00400)	(standard units, field)	n/a	n/a	nc	7.5	nc	nc	7.7	nc	7.5	nc	
pH (00403)	(standard units, laboratory)	n/a	n/a	nc	E6.6	nc	7.9	E7.2	7.5	7.3	7.5	
Specific conductance (00095)	(µS/cm at 25°C, field)	n/a	n/a	1880	1000	699	938	999	1060	1250	1290	
Total hardness, as CaCO3 (00900)	(mg/L, laboratory)	n/a	n/a	nc	310	nc	160	290	210	370	250	
Alkalinity, dissolved, as CaCO3 (29802)	(mg/L, field)	n/a	n/a	nc	A194	nc	nc	A122	nc	A184	nc	
Bicarbonate, dissolved, as HCO3 (63786)	(mg/L, field)	n/a	n/a	nc	A235	nc	nc	A149	nc	A224	nc	
Carbonate, dissolved, as CO3 (63788)	(mg/L, field)	n/a	n/a	nc	<1	nc	nc	<1	nc	<1	nc	
Trihalomethanes	Chloroform (Trichloromethane) (32106)	(µg/L)	MCL-US	80	nc	E0.02	nc	nc	1.82	2.39	E0.02	E0.03
	Bromoform (Tribromomethane) (32104)	(µg/L)	MCL-US	80	nc	ND	nc	nc	1.2	3.8	ND	ND
	Bromodichloromethane (32101)	(µg/L)	MCL-US	80	nc	ND	nc	nc	3.06	5.91	E0.03	ND
	Dibromochloromethane (32105)	(µg/L)	MCL-US	80	nc	ND	nc	nc	2.9	6.8	ND	ND
Solvents	Tetrachloroethylene (PCE) (34475)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	ND	ND	ND
	1,2-Dichloropropane (34541)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	ND	ND	ND
	Trichloroethylene (TCE) (39180)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	ND	ND	ND
	1,1-Dichloroethene (34501)	(µg/L)	MCL-CA	6	nc	ND	nc	nc	ND	ND	ND	ND
	cis-1,2-Dichloroethene (77093)	(µg/L)	MCL-CA	6	nc	ND	nc	nc	ND	ND	ND	ND
	Tetrahydrofuran (81607)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	ND	ND	ND
	Dichloromethane (34423)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	E0.03	ND	ND
	Dibromomethane (30217)	(µg/L)	n/a	n/a	nc	ND	nc	nc	0.14	0.38	ND	ND
	trans-1,2-Dichloroethene (34546)	(µg/L)	MCL-CA	10	nc	ND	nc	nc	ND	0	ND	ND
	Tetrachloromethane (Carbon tetrachloride) (32102)	(µg/L)	MCL-CA	0.5	nc	ND	nc	nc	E0.02	0	ND	ND

GAMA well identification number		Units	Threshold type	Threshold level	TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05
Gasoline	Ethylbenzene (34371)	(µg/L)	MCL-CA	300	nc	ND	nc	nc	ND	0	ND	ND
	Methyl tertbutyl ether (MTBE) (78032)	(µg/L)	MCL-US	13	nc	ND	nc	nc	ND	0	ND	ND
	Benzene (34030)	(µg/L)	MCL-CA	1	nc	ND	nc	nc	ND	0	ND	ND
	Methyl tertpentyl ether (50005)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	0	ND	ND
	Toluene (34010)	(µg/L)	MCL-CA	150	nc	ND	nc	nc	ND	V0.01	ND	V0.01
	m-and p- Xylene (85795)	(µg/L)	MCL-CA	1750	nc	ND	nc	nc	ND	0	ND	ND
	o-Xylene (77135)	(µg/L)	MCL-CA	1750	nc	ND	nc	nc	ND	ND	ND	ND
Organic synthesis	1,1-Dichloroethane (34496)	(µg/L)	MCL-US	5	nc	ND	nc	nc	ND	ND	ND	ND
	1,2,4-Trimethylbenzene (77222)	(µg/L)	NL	330	nc	E0.08	nc	nc	ND	ND	E0.09	ND
	Carbon disulfide (77041)	(µg/L)	NL	160	nc	ND	nc	nc	ND	ND	ND	ND
	Styrene (77128)	(µg/L)	MCL-US	100	nc	ND	nc	nc	ND	ND	ND	ND
Refrigerants	Bromochloromethane (77297)	(µg/L)	HA-L	9	nc	ND	nc	nc	ND	0.24	ND	ND
	Trichlorofluoromethane (CFC-11) (34488)	(µg/L)	MCL-CA	100	nc	ND	nc	nc	ND	ND	ND	ND
	Dichlorodifluoromethane (CFC-12) (34668)	(µg/L)	NL	1000	nc	ND	nc	nc	ND	ND	ND	ND
	Chloromethane (34418)	(µg/L)	HA-L	30	nc	ND	nc	nc	ND	ND	ND	ND
Tentatively identified compounds with CAS numbers1	Cyclopentane (287-92-3)	(µg/L)	n/a	n/a	nc	0.1	nc	nc	nc	nc	nc	nc
	Methane chlorodifluoro (75-45-6)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Methane dichlorofluoro (75-43-4)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	C5-Alkene (109-67-1)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	C2-cyclopropane (1191-96-4)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Sulfur dioxide (7446-09-5)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Hexafluoropropene (116-15-40)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Pentafluoropropene (690-27-7)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Hexafluoropropene and CO2	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Pentafluoropropene and CO2	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Unknown (a)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	C1-Cyclobutane (598-61-8)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc
	Unknown (b)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nc	nc	nc	nc

GAMA well identification number		Units	Threshold type	Threshold level	TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05
Herbicides	Simazine (04035)	(µg/L)	MCL-US	4	nc	nc	nc	nc	ND	nc	nc	nc
	Atrazine (39632)	(µg/L)	MCL-CA	1	nc	nc	nc	nc	ND	nc	nc	nc
	11,2-Dibromo-3-chloropropane (DBCP) (82625)	(µg/L)	MCL-US	0.2	nc	nc	nc	nc	ND	nc	nc	nc
	2Diphenamid (04033)	(µg/L)	HA-L	200	nc	nc	nc	nc	ND	nc	nc	nc
	Hexazinone (04025)	(µg/L)	HA-L	400	nc	nc	nc	nc	E0.008	nc	nc	nc
	Metolachlor (39415)	(µg/L)	HA-L	100	nc	nc	nc	nc	0.006	nc	nc	nc
	Tebuthiuron (82670)	(µg/L)	HA-L	500	nc	nc	nc	nc	ND	nc	nc	nc
	Trifluralin (82661)	(µg/L)	HA-L	5	nc	nc	nc	nc	ND	nc	nc	nc
	11,2-Dibromoethane (EDB) (77651)	(µg/L)	MCL-US	0.05	nc	nc	nc	nc	ND	nc	nc	nc
	2Imazaquin (50356)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
	Phorate (82664)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
Pesticide degradates	2-Chloro-4-isopropylamino- 6-aminos-triazine (deethylatrazine) (04040)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
	22-Chloro-6-ethylamino-4-amino-striazine (deisopropylatrazine) (04038)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
	2,6-Diethylaniline (82660)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
	3,4-Dichloroaniline (61625)	(µg/L)	n/a	n/a	nc	nc	nc	nc	ND	nc	nc	nc
Wastewater-indicator Constituents	Isophorone (34409)	(µg/L)	HA-L	100	nc	E0.1	nc	nc	nq	nc	nq	nc
	Benzophenone (62067)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	nc	ND	nc
	4-Nonylphenol (62085)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	nc	ND	nc
	1Caffeine (50305)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	nc	ND	nc
	Bisphenol A (62069)	(µg/L)	n/a	n/a	nc	ND	nc	nc	ND	nc	ND	nc
	Tris (dichloroisopropyl) phosphate (62088)	(µg/L)	n/a	n/a	nc	ND	nc	nc	nq	nc	ND	nc
	2Phenol (34466)	(µg/L)	HA-L	2000	nc	V0.7	nc	nc	ND	nc	ND	nc

	GAMA well identification number	Units	Threshold type	Threshold level	TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05
Inorganic Constituents	Bromide, dissolved (71870)	(mg/L)	n/a	n/a	nc	0.39	nc	0.51	0.44	0.46	0.5	0.71
	Calcium, dissolved (00915)	(mg/L)	n/a	n/a	nc	80.9	nc	38.5	66.5	49	94	57.9
	Chloride, dissolved (00940)	(mg/L)	SMCL-US	250	nc	102	nc	82.1	114	126	124	168
	Fluoride, dissolved (00950)	(mg/L)	MCL-US	2	nc	0.2	nc	E0.1	0.2	0.1	0.2	0.1
	Iodide, dissolved (71865)	(mg/L)	n/a	n/a	nc	0.015	nc	0.12	0.017	0.044	0.016	0.032
	Magnesium, dissolved (00925)	(mg/L)	n/a	n/a	nc	26.8	nc	16.2	30.6	21.9	33.2	24.7
	Potassium, dissolved (00935)	(mg/L)	n/a	n/a	nc	3.17	nc	3.39	4	3.67	3.41	4.49
	Silica, dissolved (00955)	(mg/L)	n/a	n/a	nc	23.4	nc	34.3	21.3	24	24.8	20.1
	Sodium, dissolved (00930)	(mg/L)	n/a	n/a	nc	138	nc	134	120	145	156	170
	Sulfate, dissolved (00945)	(mg/L)	SMCL-US	250	nc	248	nc	191	252	223	309	244
	Total dissolved solids (residue on evaporation) (70300)	(mg/L)	SMCL-US	500	nc	751	nc	604	721	675	889	778
	Aluminum, dissolved (01106)	(µg/L)	MCL-US	1000	nc	ND	nc	3	ND	E3	E1	ND
	Antimony, dissolved (01095)	(µg/L)	MCL-US	6	nc	ND	nc	ND	ND	ND	ND	ND
	Arsenic, dissolved (01000)	(µg/L)	MCL-US	10	nc	0.8	nc	7.2	1.3	2.5	0.8	1.7
	Barium, dissolved (01005)	(µg/L)	MCL-CA	1000	nc	25	nc	44	30	28	26	26
	Beryllium, dissolved (01010)	(µg/L)	MCL-US	4	nc	ND	nc	ND	ND	ND	ND	ND
	Boron, dissolved (01020)	(µg/L)	NL	1000	nc	2190	nc	916	1340	1180	2310	1180
	Cadmium, dissolved (01025)	(µg/L)	MCL-US	5	nc	ND	nc	ND	ND	ND	ND	ND
	Chromium, dissolved (01030)	(µg/L)	MCL-CA	50	nc	7.2	nc	ND	6.7	1.2	7.1	1.9
	Cobalt, dissolved (01035)	(µg/L)	n/a	n/a	nc	0.247	nc	0.107	0.211	0.142	0.29	0.163
	Copper, dissolved (01040)	(µg/L)	MCL-US	11300	nc	3	nc	1.1	3	1.2	3.8	1.1
	Iron, dissolved (01046)	(µg/L)	SMCL-US	300	nc	E4	nc	8	E3	9	15	ND
	Lead, dissolved (01049)	(µg/L)	MCL-US	115	nc	0.89	nc	0.27	1.15	0.44	1	0.65
	Lithium, dissolved (01130)	(µg/L)	n/a	n/a	nc	32.3	nc	5.4	20.8	16.6	35.3	18.8
	Manganese, dissolved (01056)	(µg/L)	NL	500	nc	VE0.2	nc	194	ND	1.9	1.5	2.1
	Mercury, dissolved (71890)	(µg/L)	MCL-US	2	nc	ND	nc	nc	E0.01	nc	ND	nc
	Molybdenum, dissolved (01060)	(µg/L)	HA-L	40	nc	1.9	nc	4.5	1.5	2.3	1.8	1.5
	Nickel, dissolved (01065)	(µg/L)	MCL-CA	100	nc	0.77	nc	1.11	0.8	1.7	1.05	1.44
	Selenium, dissolved (01145)	(µg/L)	MCL-US	50	nc	1.2	nc	0.7	1.3	1.7	1.6	3.2
	Strontium, dissolved (01080)	(µg/L)	HA-L	4000	nc	1060	nc	664	1630	1190	1310	1590
	Thallium, dissolved (01057)	(µg/L)	MCL-US	2	nc	ND	nc	ND	ND	ND	ND	ND
	Tungsten, dissolved (01155)	(µg/L)	n/a	n/a	nc	ND	nc	0.6	ND	ND	ND	ND

GAMA well identification number	Units	Threshold type	Threshold level	TRCY-01	TRCY-03	TRCY-08	TRCY-11	TRCYFP-02	TRCYFP-03	TRCYFP-04	TRCYFP-05
Uranium, dissolved (22703)	(µg/L)	MCL-US	30	nc	3.37	nc	0.21	1.69	1.05	3.68	0.97
Vanadium, dissolved (01085)	(µg/L)	NL	50	nc	2.7	nc	0.3	4.6	8.3	3.1	6.3
Zinc, dissolved (01090)	(µg/L)	HA-L	2000	nc	VE2.0	nc	10.3	12.4	17.2	2.8	3.1

Notes:

TRCY, Tracy Basin; TRCYFP, Tracy Basin flowpath

The five digit number below the constituent name is the USGS parameter code used to uniquely identify a specific constituent or property.

ft, feet; LSD, land surface datum; mm/dd/yy, month/day/year; °C, degrees Celsius; mg/L, milligram per liter; µg/L, microgram per liter; mm, millimeter; NTU, nephelometric turbidity units; µS/cm, microsiemens per centimeter

The threshold type identifies the source of the comparison threshold. The threshold level is the level with which ground-water detections are compared.

HA-L, lifetime health advisory (U.S. Environmental Protection Agency, 2004b); MCL-CA, California Department of Health Services Maximum Contaminant Level (California Department of Health Services, 2005a); MCL-US, U.S. Environmental Protection Agency Maximum Contaminant Level (U.S. Environmental Protection Agency, 2005); NL, notification level (California Department of Health Services, 2005d).

USGS, U.S. Geological Survey.

Concentrations preceded by “V” indicate detections potentially biased by contamination; A indicate averaged value; E, indicate estimated value.

n/a, not applicable or not available; nc, sample not collected, not analyzed; ND, analyzed but not detected;